Allied-Signal Inc.

Morristown, NJ

Feasibility Study for Areas 1, 1A, 2 & 5 UOP Site, East Rutherford, NJ

Addendum: VOCs in Soil

ENSR Consulting and Engineering

(Formerly ERT)

April 1990

Document Number 0186-002-284-A

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

1

1. INTRODUCTION

1.1 Introduction

This Addendum was prepared for Allied-Signal Inc., the corporate successor of UOP, in response to New Jersey Department of Environmental Protection (NJDEP) concern for the concentrations of volatile organic compounds (VOCs) in the UOP Site soils.

The Feasibility Study for Areas 1, 1A, 2 & 5, UOP Site, East Rutherford, NJ (ENSR, 1990) was a human health and ecological risk-based study. The scope of the Feasibility Study (FS) was therefore limited to the identification and evaluation of remedial alternatives that address contaminants and media that alone or in combination pose a significant human health or an ecological risk.

The U.S. EPA defines acceptable risk as those levels within the 10^{-4} to 10^{-6} range, with the 10^{-6} as the point of departure for determining remediation goals (40 CFR 300.430(e)). Only polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in surface soils were found to exceed the low end of the range (10^{-6}). VOCs were not found to pose a risk and, therefore, were not addressed.

Nonetheless, in response to NJDEP concerns, this FS Addendum was prepared to address VOCs in soils. Like the FS, the Addendum was prepared in accordance with the May 1986 Administrative Consent Order (ACO) between UOP and NJDEP and the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and its governing regulations, the National

Contingency Plan (NCP), as revised (40 CFR 300). The NCP provides decision-making guidance and a framework for the identification and evaluation of remedial action alternatives on a site-by-site basis. In addition, the procedures enumerated in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, 1988b) were followed.

The Addendum addresses the former process and storage areas of the UOP Site, referred to as the terrestrial upland or "upland" portions, designated as Areas 1, 1A, 2, and 5. The UOP Site is the former location of an aroma chemicals laboratory in East Rutherford, New Jersey that operated from 1932 to 1979. Present site conditions have been under investigation since the early 1980s. The results of the Remedial Investigation (Geraghty & Miller, 1985; 1988) and the Risk Assessment (ENSR, June 1989; November 1989) are the bases for the Addendum. Site background information and conclusions of the Remedial Investigation and Risk Assessment Reports are summarized in Section 1 of the FS, referred to hereafter as FS Section 1.

The remainder of this Section evaluates the distribution of VOCs in the upland areas, develops remediation goals, and identifies remediation areas based on the distribution of VOCs and the remediation goals. Subsequent sections of this Addendum identify technologies and develop and evaluate alternatives to address the remediation goals. Section 2 identifies general response measures and technologies for the soils containing VOCs and screens the technologies to retain those that are potentially effective and implementable. Section 3 develops and evaluates alternatives from the technologies retained in screening. Alternatives are evaluated according to seven EPA criteria as well as criteria outlined in the ACO. Section 4 comparatively evaluates the alternatives in light of the detailed evaluation results and recommends preferred alternatives. Section 5 summarizes the conclusions of the FS and the VOC Addendum and develops an overall approach to Site remediation.

1.2 Nature and Extent of VOC Soil Contamination

The upland portions of the UOP Site were described and the distribution of contaminants detected in these areas were presented in FS Sections 1.2.4 and 1.2.5. The VOCs of NJDEP concern were detected in much of the soils analyzed from Areas 1, 1A, 2, and 5, shown in Figure 1-1. The VOCs detected in the soils are primarily benzene, toluene, ethyl benzene, and xylene (BTEX). The distribution of VOCs detected are presented below by area.

Area 1

The compounds measured in highest concentration in Area 1 were chlorobenzene (12 and 63 milligrams per kilogram (mg/kg)), benzene (7.9 mg/kg), and xylene (49 mg/kg). These compounds were detected in borings B1-1, B1-5, and B1-7. The total VOC concentrations ranged from 0.005 to 15 mg/kg in the unsaturated zone and from 0.089 to 66.6 mg/kg in the saturated zone.

Area 1A

All soils sampled in Area 1A contained VOCs, ranging in concentration from 0.007 to 980 mg/kg in the unsaturated zone and from 0.009 to 1,747 mg/kg in the saturated zone. BTEX were the predominant compounds. For example, the 1,747 mg/kg total VOC concentration is comprised of 1,600 mg/kg toluene.

Area 2

VOCs were detected in the soils sampled in the center and along the northern boundary of Area 2. Total VOC concentrations ranged from below detection levels (BDL) to 70.7 mg/kg in the unsaturated zone and from 0.029 to 2,108 mg/kg in the saturated zone. As in Area 1A, toluene accounted for most of the total VOCs detected.

Area 5

Fewer VOCs were detected in Area 5 soils. Total VOC concentrations ranged from BDL (0.100 mg/kg) to 0.592 mg/kg in the unsaturated zone and from 0.006 to 18 mg/kg in the saturated zone. Ninety-five percent of the highest total VOC concentration was toluene. Acetone was the predominant VOC in most samples analyzed. The acetone measured is believed to result from analytical protocols rather than from acetone in the soils.

1.3 Determination of Remediation Goals

1.3.1 Remediation Objectives

Remediation goals are derived based on technical and institutional objectives for a particular site. Technical and institutional objectives for the upland portions of the UOP Site were identified in the FS Section 1.5. The VOCs measured in the UOP Site soils presently meet the objectives identified in the FS and therefore were not previously addressed. On this basis, the VOCs in the UOP Site soils presently meet technical objectives.

Institutional objectives are Applicable or Relevant and Appropriate Requirements (ARARs) that pertain to the constituents and or media of concern. There are neither Federal nor state ARARs that specify cleanup levels for soil. When there are no Federal and state ARARs, Federal guidance recommends the use of TBCs in determining preliminary remedial action objectives. EPA guidance provides that cleanup goals may be "based upon non-promulgated criteria and advisories (for example, health advisories such as reference doses) rather than on ARARs because ARARs do not exist for those substances or because an ARAR alone would not be sufficiently protective in the given circumstances" (U.S. EPA, 1988a). Thus, TBCs should be relied upon to ensure that the remedial action achieves an appropriate level of protection both when implemented and when completed.

In addition, EPA guidance provides that "where a TBC value is used to set a protective level of cleanup or where the ARAR does not specify the point of compliance, there is discretion to determine where the requirements shall be attained to ensure protectiveness" (EPA, August 1988). Cleanup goals can then be established using best professional judgment to ensure protectiveness for each point of exposure assuming a reasonable maximum exposure scenario. TBCs for the VOCs in the soils are presented below.

New Jersey Soil Action Levels

The NJDEP has developed soil action levels which provide guidance for soil remediation on a case-by-case basis until minimum standards are issued pursuant to Section 5(1) of Act NJSA 12:1k-10. The guidance allows for determination of site specific levels to ensure that the potential for harm to public health and the environment is minimized to the maximum extent practical, taking into account the facility location, surrounding ambient conditions, and other relevant factors.

Risk Assessment Levels

The risk assessment was performed based on site specific information to derive risk levels for the compounds that were measured in highest concentrations or pose the greatest potential risk. The VOCs measured at the UOP Site were evalauted in the human health and ecological risk assessments (ENSR, June 1989; November 1989). As described in the FS Section 1.3, the risk assessment concluded that the VOCs did not pose a human health or an environmental risk that was within or greater than the 10^{-4} to 10^{-6} risk range deemed acceptable by the EPA (40 CFR 300.430(e)). For example, benzene was the only VOC that was identified as posing a potential risk. Under the present use scenario, exposure to benzene was calculated to pose a maximum total risk of 4.7×10^{-11}. Under the future use scenario, exposure to benzene was calculated to pose a total risk of 6.6×10^{-9}. The highest risk was calculated using the construction worker scenario, in which the maximum total risk from exposure to benzene was 1.66×10^{-8}. These risks are two orders of magnitude or more below the EPA endorsed point of departure for setting cleanup goals.

1.3.2 Remediation Goals

The following section develops remediation goals for the VOCs in soils at the UOP Site. The goals will serve as the foundation for identifying technologies and developing remedial alternatives in subsequent stages of this analysis; the remediation goals will ultimately provide the bases for selecting a preferred alternative. The goals address the technical and institutional objectives and reflect the specific conditions of the UOP Site.

As stated above, the VOCs in Site soils presently meet the technical objective, defined in FS Section 1.5.1, to prevent human exposure to surface soils that pose a singificant human health risk. The VOCs in soils also meet institutional objectives, as described below.

The NJ soil action levels are non-promulgated guidance determined to be pertinent to a site on a case-by-case basis. Guidance provides for development of site specific soil action levels to ensure that the potential for harm to public health and the environment is minimized. Given the provision for use of site specific risk-based levels, the soil action levels are not appropriate for the UOP Site.

The risk assessment provides the most appropriate TBC information for the UOP Site soils since the levels were developed specifically for the Site. The risk assessment derived site specific, risk-based levels to ensure the protection of human health and the environment based on potential site specific risks. As stated above and in the FS Section 1.3, the risk assessment concluded that VOCs do not pose a significant human health or environmental risk. The NCP states: "The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives <u>when ARARs are not available</u>..." (40 CFR 300.430 (e)(2)(i)(A)(2)). The VOCs do not presently exceed the 10^{-6} risk level. The NJ soil action levels are not appropriate given the Federal and state guidance that support risk-based remediation goals. Based on the risk assessment, the VOCs presently meet institutional objectives.

While the VOCs presently meet technical and institutional objectives, the NJDEP has voiced concerns about the VOCs in the

UOP Site soils. As presented in Section 1.2, certain areas contain elevated VOC concentrations. Given the circumstances of the Site and the findings of the risk assessment, the remediation objective will address the elevated concentrations of VOCs detected in certain portions of the UOP Site soils. To address these areas of elevated concentration, a remediation goal of 100 mg/kg total VOCs was selected. Remediation to 100 mg/kg total VOCs would achieve an order of magnitude reduction in maximum VOC concentrations in UOP Site soils and would reduce average concentrations to the low mg/kg range. Soils measured to contain greater than 100 mg/kg VOCs are identified below.

1.4 Identification of Remediation Areas

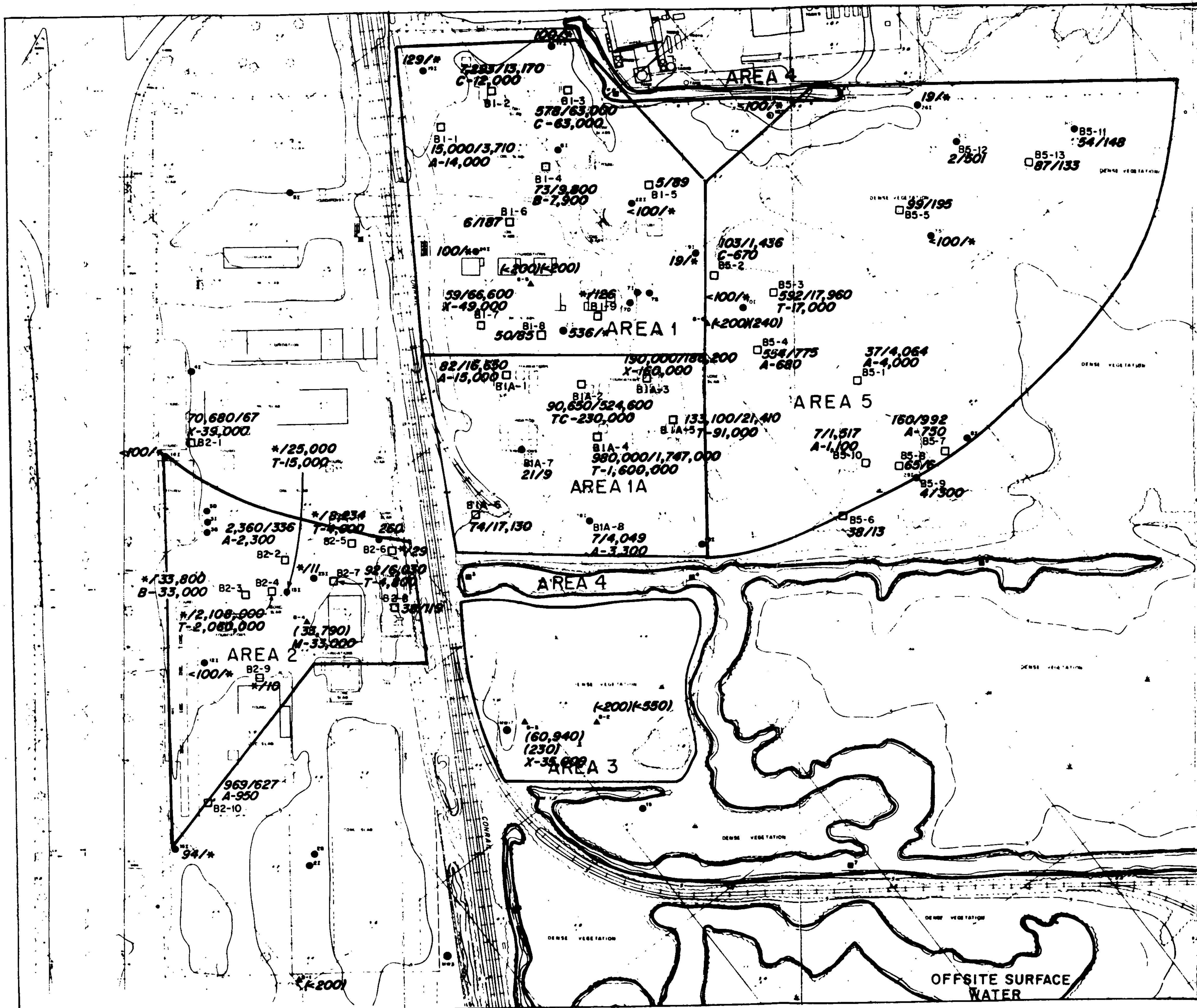
As described above, the identification of remediation areas will focus on soils that contain 100 mg/kg or greater total VOCs. According to the data collected for and reported in the Remedial Investigation Report (Geraghty & Miller, 1988), no samples collected from either Area 1 or Area 5 contained greater than 100 mg/kg total VOCs. Concentrations of acetone reported were omitted from calculation of the total VOC concentration due to the probable introduction of acetone during field decontamination or laboratory procedures. Total VOCs in concentrations greater than 100 mg/kg were measured in Areas 1A and 2.

Toluene was detected in high concentrations in Area 1A. Borings B1A-4 and B1A5 were reported to contain a maximum of 91 and 1,600 mg/kg of toluene, respectively. In addition, adjacent borings contained total VOCs above the remediation goal. B1A-2 contained 230 mg/kg 1,1,2,2-tetrachloroethane and 525 mg/kg total VOCs. B1A-3 was reported to contain 160 mg/kg xylene and a total VOC concentration of 190 mg/kg.

Total VOC concentrations exceeded 100 mg/kg in one sample collected in Area 2. Boring B2-4 measured 2,108 mg/kg total VOCs, of which 2,060 mg/kg were reported to be toluene.

Based on the remediation goal and the distribution of sampling points in adjacent areas, boxes were drawn to enclose the remediations areas, in the same manner applied in delineating remediation areas in the FS. The defined remediation areas are shown in Figure 1-2.

Limited data are available on the vertical distribution of VOCs, and limited information can be inferred from the soil characteristics. The soils in Areas 1A and 2 are primarily saturated; the maximum depth to ground water is 2 feet. The soils encountered in borings were composed primarily of silt, sand, and clay. In some cases paper and glass debris were reported as well as gravel and rock. Otherwise, little debris was encountered in these areas in comparison to the volumes of debris reported in Area 5. A 2- to 3-foot thick meadow mat, composed of dense decaying plant matter and peat, ranges from 5 to 8 feet beneath the surface. It is unlikely that VOCs migrated below the meadow mat. Peat generally absorbs organic compounds and would retard vertical migration of the VOCs. However, the maximum depth to the clay confining layer (the maximum depth to which VOCs may have migrated), in Areas 1A and 2 is 10 and 13 feet, respectively. Depending upon the remedial alternative selected, additional sampling and analyses will be required to define the vertical limit of the VOCs in excess of the remediation goal. For this analysis, the vertical limit of the remediation area will conservatively assumed to be the clay confining layer.



EXPLANATION

MONITORING WELL LOCATION AND DESIGNATION
S,I SHALLOW
D DEEP

STAFF GAUGE LOCATION AND DESIGNATION

B5-3 SOIL BORING LOCATIONS AND DESIGNATIONS

103/1,436 TOTAL CONCENTRATION OF VOLATILE ORGANIC COMPOUNDS (ug/kg) IN
SATURATED SOIL SAMPLE
UNSATURATED SOIL SAMPLE

C-670 COMPOUND IN HIGHEST CONCENTRATION IS SHOWN FOR EACH LOCATION. CONCENTRATION MUST BE ABOVE 500 ug/kg TO BE LISTED.

- A - ACETONE
- B - BENZENE
- C - CHLOROBENZENE
- M - METHYLENE CHLORIDE
- T - TOLUENE
- TC - 1,1,2,2-TETRACHLOROETHANE
- X - XYLENE

* NO SAMPLE

(<200)(240) NO DISTINCTION MADE BETWEEN SATURATED AND UNSATURATED SAMPLES

0 100 FEET

SOURCE: GERAGHTY & MILLER, 1988

NO.	DATE	REVISIONS	BY	CH'KD	APP'V'D

ENSR

ENSR CONSULTING & ENGINEERING
35 NAGOG PARK
ACTON, MASSACHUSETTS 10720

VOCS IN SOILS
UOP SITE
EAST RUTHERFORD, N.J.

DESIGN:	DATE: 4/19/90	FIGURE NUMBER 1-1	
DRAWN: J.B.	SCALE:	SHEET NUMBER	REV. NO.
CHECKED: D.U.	APPROVED:		

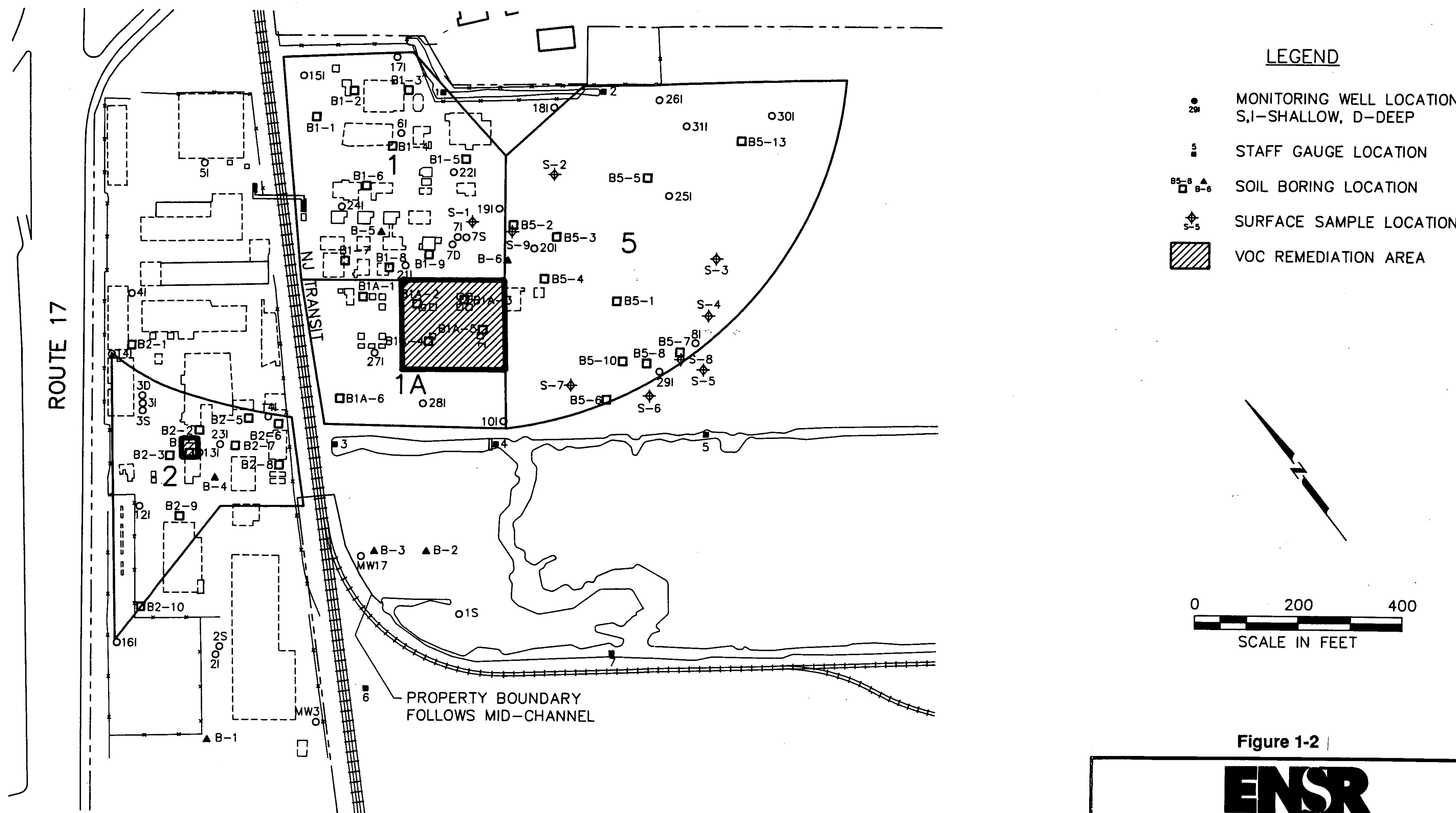


Figure 1-2

ENSR

ENSR CONSULTING & ENGINEERING

VOC REMEDIATION AREAS
UOP SITE
EAST RUTHERFORD, N.J.

DRAWN BY:	DATE:	PROJECT NO.
K.L.U.	3/90	0186–002–284

018621B

2

2. IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL RESPONSE TECHNOLOGIES

2.1 Introduction

General response measures were determined and technologies identified for the soils and debris at the UOP Site in Section 2 of the Feasibility Study for Areas 1, 1A, 2 & 5, UOP Site, East Rutherford, NJ (ENSR, 1990). The same general response measures can be applied to the VOC-contaminated soils in Areas 1A and 2. The general response measures are listed in Table 2-1 and were described in FS Section 2.2. The technologies and process options identified for the UOP Site soils were presented and screened in FS Section 2.3. The previously identified technologies as well as additional technologies that directly pertain to VOC-contaminated soils are briefly described and screened in the following subsections by general response measure. Technologies and process options are screened for potential effectiveness and implementability in the same manner applied in Section 2. Table 2-2 presents and describes the technologies and process options addressed. Table 2-3 summarizes the technology and process option screening.

2.2 Technology Identification and Screening

2.2.1 Containment

Covering and capping are well-demonstrated containment measures that may isolate the VOCs in the soils from human exposure and limit the accumulation of VOCs in the stream channel sediments. The covering and capping measures identified are briefly described and screened below.

TABLE 2-1
UOP SITE
EAST RUTHERFORD, NJ
GENERAL RESPONSE MEASURES AND TECHNOLOGIES
FOR VOC-CONTAMINATED SOILS

General Response Measure	Remedial Technology	Process Option
No Action/ Institutional Controls		
Containment	Cap/Cover	Soil Cover Single-layer Cap Multi-layer Cap
Removal	Excavation	
Treatment of Excavated Soils	Bioremediation	Land Farming Bioreactor
	Incineration	Rotary Kiln Shirco Infrared Conventional Fluidized Bed Circulating Fluidized Bed Advanced Electric Reactor
	Solidification	
	Soil Washing	Solvents
	Thermal Separation	Thermal Desorption Steam Stripping
	Vacuum Extraction	
Disposal of Excavated Soils	Landfill	Onsite Offsite
In-Situ Treatment	Bioremediation	
	Solidification	
	Vacuum Extraction	
	Vitrification	

TABLE 2-2 REMEDIAL TECHNOLOGIES FOR VOC-CONTAMINATED SOILS
UOP SITE
EAST RUTHERFORD, NEW JERSEY

General Response Measure	Technology	Process Option	Description	Application
No Action/ Institutional Controls			No further action taken or limited controls instituted to limit exposure to soils that pose a significant risk. Provides a basis for comparison of action and no action alternatives.	Site that poses neither direct nor indirect exposure risks or poses limited risk such that institutional controls prevent potential exposure.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Containment	Cap/Cover	Soil Cover	Layers of soil and borrow are spread over the VOC-contaminated area to prevent exposure to soils.	Soils containing organic and inorganic compounds.
	Cap/Cover	Single-layer Asphalt or Concrete Cap	Asphalt or concrete covers the soils to prevent exposure to and water infiltration through the contaminated	soils.Soils containing organic or inorganic constituents.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Containment (Continued)	Cap/Cover	Multi-layer Cap	Multiple layers of varying permeability materials cover the soils to prevent exposure to and water infiltration through the contaminated soils.	Soils containing organic or inorganic constituents.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Containment (Continued)	Slurry Walls		A barrier installed by excavating a trench under a slurry of bentonite and water. The slurry shores the trench to prohibit migration of contaminated soils.	Areas where the depth to a confining zone (e.g., clay) is relatively shallow and where there are few buried utilities and foundations.
	Grout Curtains		Physical barrier constructed by injecting a sealing fluid into the soil to prevent migration of contaminated soils.	Areas with porous soil or rock where slurry walls are inappropriate.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Containment (Continued)	Sheet Pilings		Physical barrier of steel sheet pilings to prevent migration of contaminated soil and ground water.	Areas where the depth to a confining layer is relatively shallow and where the soil is free of rocks, boulders, and underground utilities and foundations.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Removal	Excavation		Excavation using standard construction equipment with or without ground water removal and treatment on- or off-site as the site conditions and subsequent handling methods dictate.	Organic and inorganic constituents in a solid matrix.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Treatment of Excavated Soils	Solidification/ Stabilization		Contaminated soil is chemically treated and or immobilized with pozzolanic or silicate-based agents in a tank using mixing paddles and augers. Material solidifies and is handled as solid monolith.	Soils containing inorganic and organic constituents. Limited application in treating volatile and semi-volatile compounds.
Treatment of Excavated Soils (Continued)	Bioremediation	Land Farming	Microbial degradation of organic compounds is enhanced by spreading shallow layer of contaminated soil in lined	treatment unit where nutrients and oxygen are made available. Soils containing biodegradable organic compounds.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Treatment of Excavated Soils (Continued)	Bioremediation (Continued)	Bioreactor	Microbial degradation of organic compounds is enhanced by mixing contaminated soil in a slurry in above-ground treatment tank where nutrients and oxygen are introduced under controlled temperature and pH conditions.	Soils containing organic compounds.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Treatment of Excavated Soils (Continued)	Low Temperature Oxidation	Supercritical Water	Oxidation of organic compounds is accelerated by pressurizing slurried soils and compressed air or oxygen to supercritical conditions.	Liquids, sludges, or soils containing organic compounds.
		UV Oxidation	Oxidation of organic compounds is enhanced using a controlled combination of ultraviolet light and ozone and or hydrogen peroxide.	Liquids or sludges that permit transmission of UV light that contain organic compounds.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Treatment of Excavated Soils (Continued)	Incineration	Rotary Kiln, Shirco Infrared, Conventional Fluidized Bed, Circulating Fluidized Bed, Advanced Electric Reactor	Organic and some inorganic constituents are combusted at high temperatures and oxidized to gases or reduced to ash.	Liquids, sludges, solids, or gases generally having a thermal value.
Treatment of Excavated Soils (Continued)	Thermal Separation	Thermal Desorption	Organic and some inorganic constituents are volatilized under controlled temperatures and collected as gases or condensate for subsequent treatment.	Sludges and soils containing organic and inorganic constituents that volatilize within the unit operating temperatures.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
		Steam Stripping	Organic and some inorganic constituents are volatilized using elevated temperatures and steam and collected as gases or condensate for subsequent treatment.	Sludges and soils containing organic and inorganic constituents that volatilize within the unit operating temperatures.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Treatment of Excavated Soils (Continued)	Soil Washing	Organic Solvents	Soil is rinsed with water, solvents, acids-bases, complexing agents, surfactants, or reducing agents to extract target compounds for subsequent treatment. Processes differ with vendor.	Sludges and soils containing organic and some inorganic constituents.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
Treatment of Excavated Soils (Continued)	Vacuum Extraction		Volatile compounds are extracted through a vacuum system installed within piled soil and vented to an emission control system or to the atmosphere.	Soils containing volatile and some semi-volatile compounds.
Disposal of Excavated Soils	Landfill	Onsite	Excavated soil is disposed of in secure landfill constructed onsite.	Organic and inorganic constituents in medium void of free liquids.
		Offsite	Excavated soil is disposed of in secure landfill offsite.	Organic and inorganic constituents in medium void of free liquids.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
In-Situ Treatment	Bioremediation		In-situ microbial degradation of organic and some inorganic compounds is enhanced by optimizing nutrient and oxygen concentrations in soil matrix. Enrichment medium is delivered to source area via injection wells or trenches and circulated hydraulically.	Medium to high permeability shallow soils generally containing biodegradable, generally lower molecular weight, organic compounds.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
In-Situ Treatment (Continued)	Solidification		Soils are chemically treated and or immobilized with reagents and or pozzolanic- or silicate-based agents using augers and mixing paddles. Mixture solidifies in-situ.	Relatively homogeneous soils containing inorganic and some organic compounds. Treatment of organic compounds, particularly VOCs not well demonstrated.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
In-Situ Treatment (Continued)	**Vacuum Extraction**		**Volatile compounds are extracted through a vacuum system. A network of pipes is installed in the soils and connected to a manifold system to extract VOCs.**	Medium to high permeability unsaturated soils containing volatile and some semi-volatile organic compounds.

TABLE 2-2 (Continued)

General Response Measure	Technology	Process Option	Description	Application
In-Situ Treatment (Continued)	Vitrification		Thermal treatment and encapsulation of contaminated soils by passing an electric current between electrodes placed in the affected area. Current raises temperatures to level sufficient to melt soils.	Generally restricted to use in immobilizing radionuclide-contaminated soils and other extremely toxic media.

TABLE 2-3 PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR VOC-CONTAMINATED SOILS UOP SITE EAST RUTHERFORD, NEW JERSEY

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
No Action/ Institutional Controls			Appropriate given that existing conditions pose neither human health nor environmental risks. Also provides a basis for comparison of action and no action alternatives.	Appropriate
Containment	Cap/Cover	Soil Cover	Appropriate given that existing conditions pose neither human health nor environmental risks. Soil cover would neither prevent volatilization of	VOCs nor infiltration of water through the soils. Not Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Containment (Continued)	Cap/Cover (Continued)	Single-layer Asphalt or Concrete Cap	Single-layer cap would prevent volatilization of VOCs and infiltration through the soils. Alone would not prevent migration of VOCs with localized ground water flow and tidal fluctuations. However, effective If combined with a vertical barrier. Cover could be designed and constructed to minimize impacts on adjacent areas.	Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Containment (Continued)	Cap/Cover	Multi-layer Cap	Effective containment method for preventing volatilization of VOCs and water infiltration through the soils. Difficulties associated with design and construction to minimize effects on adjacent areas.	Not Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Containment (Continued)	Slurry Walls		Could prevent vertical migration of VOCs soils and ground water. Implementation could be problematic in areas where there are buried utilities, underground obstructions, and foundations. May be effective in conjuction with other containment methods, e.g., a cap. However, may be susceptible to degradation under saline conditions.	Appropriate where there are few buried utilities, underground obstructions, and foundations.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Containment (Continued)	Grout Curtains		The heterogeneity and low permeability of the soils overlying the confining clay layer limits the feasibility of constructing a "gap-free" grout curtain. The variable ground waterflow directions, extensive area to be contained, and the potential for encountering buried utilities and drains further complicate implementability.	Not Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
	Sheet Pilings		The presence of buried utilities, subsurface drains, and the hetergeneity and low permeability of the soils preclude the use of sheet pilings. Same factors that apply to grout curtains restrict implementability.	Not Appropriate.
Removal	Excavation		Excavation would effectively remove VOCs of concern to NJDEP. Excavation activities would be complicated by shallow ground water, buried utilities and subsurface drains, and building foundations.	Appropriate.
Treatment of Excavated Soils	Solidification/ Stabilization		Immobilization of VOCs not demonstrated. Recent projects indicate VOCs volatilize prior to solidification.	Not Appropriate

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Treatment of Excavated Soils (Continued)	Bioremediation	Land Farming	Biodegradation of VOCs is well-demonstrated. However, land treatment of VOCs requires rigorous emission controls and large soil volumes require expansive treatment area. Emission controls over large treatment area limits implementability.	Not Appropriate.
		Bioreactor	VOCs readily biodegradable. Requires homogeneous soil mixture to ensure proper contact between medium and microorganisms. Emission controls required to limit release of VOCs during treatment.	Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Treatment of Excavated Soil (Continued)	Low Temperature Oxidation	Supercritical Water	VOCs readily oxidized, however, process not demonstrated for soils and sludges.	Not Appropriate.
Treatment of Excavated Soil (Continued)	Low Temperature Oxidation (Continued)	UV Oxidation	Same restrictions as above. In addition, soil particles restrict transmission of UV light, limiting the effectiveness of the system as designed.	Not Appropriate.
	Incineration	Rotary Kiln, Shirco Infrared, Conventional Fluidized Bed, Circulating Fluidized Bed, Advanced Electic Reactor	Effectively treats VOCs. Emission controls required to limit release of VOCs preceding and during treatment. Permitting (onsite) and capacity (offsite) problems may complicate implementability.	Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Treatment of Excavated Soils (Continued)	Thermal Separation	Thermal Desorption	Effective method for separating VOCs from soils. The collected condensate requires further treatment.	Appropriate.
		Steam Stripping	No known demonstrated commercial units presently available.	Not Appropriate.
	Soil Washing	Organic Solvents	Effective method of separating VOCs from soils. Oil requires further treatment.	Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
Treatment of Excavated Soils (Continued)	Vacuum Extraction		Potentially effective for excavated, piled soils containing VOCs. Densely-spaced extraction network would be required to effectively remove VOCs. Residual moisture in low permeability soils may limit reduce treat efficiency.	Appropriate.
Disposal of Excavated Soils	Landfill	Onsite	Site conditions, including shallow ground water, floodplain, and frostline relationships, likely prevent construction of an onsite landfill.	Not Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
	Landfill	Offsite	Commercial facilities are readily available. Extensive dewatering required prior to transport.	Appropriate.
In-Situ Treatment	Bioremediation		VOCs present are readily biodegraded, however, sufficient soil permeability required to engineer delivery of enrichment medium to affected area. Available methods for increasing soil permeability (e.g., pneumatic fracturing) would not ensure uniform and effective delivery of enrichment medium, or practical long-term operation.	Not Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
	Solidification		Not proven effective for VOCs; VOCs likely to volatilize during treatment. Rigorous emission controls required to prevent uncontrolled release of VOCs. Site conditions, e.g., shallow ground water and flood plain limit implementability and potential long-term effectiveness.	Not Appropriate.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
In-Situ Treatment (Continued)	Vacuum Extraction	.	Potentially effective method for removing VOCs in medium to high permeability unsaturated soils. Pneumatic fracturing could locally increase soil permeability. Dewatering would be required to effectively extract VOCs. Underground utility lines and subsurface drains could complicate dewatering activities close to stream channels.	Potentially appropriate if implemented in conjunction with dewatering and pneumatic fracturing.
			Potentially effective method for activities close to stream channels.	Appropriate if implemented in conjunction with dewatering and pneumatic fracturing.

TABLE 2-3 (Continued)

General Response Measure	Technology	Process Option	Preliminary Screening of Technologies	Result
	Vitrification		High temperatures likely to volatilize rather than encapsulate VOCs. Buried utilities, subsurface drains, shallow ground water, and proximity to the stream channels limit implementability.	Not Appropriate.

Soil Cover

A soil cover would involve spreading and compacting 6 inches of backfill over the targeted portions of Areas 1A and 2, grading the areas to be covered to achieve a maximum 2 percent slope for drainage. One foot of common borrow would be spread over the graded areas, covered by 4 inches of loam. The loam would be seeded to minimize erosion of the soil cover. The maximum 20-inch cover would prevent contaminated soils from surfacing during freeze-thaw cycles. However, VOCs could volatilize from the covered soils. Monitoring and maintenance would be required to ensure cover integrity and effectiveness.

Effectiveness: A soil cover effectively decreases the potential for direct exposure to VOC-contaminated soils. However, the soil cover would neither prevent volatilization of VOCs from nor infiltration of water through the soils.

Implementability: A soil cover could be easily constructed over the targeted portions of Areas 1A and 2.

A soil cover was not retained for further evaluation because the soil would provide little additional benefit over existing conditions for reducing exposure to or migration of VOCs in soil.

Single-layer Asphalt or Concrete Cap

A single-layer asphalt or concrete cap would be constructed over the targeted portions of Areas 1A and 2 in the same manner described in Sections 2.3.1 and 3.3.3. Limited site clearing would be required prior to construction. Little debris and vegetation cover these portions of the UOP Site. Existing foundations could remain undisturbed. The targeted portions would be graded with additional backfill prior to constructing the cap. The cap would require periodic monitoring and maintenance to ensure structural integrity and effectiveness.

<u>Effectiveness</u>: A single-layer cap would effectively reduce or eliminate exposure to VOCs in soil and infiltration of water through the contaminated soils.

<u>Implementability</u>: A single-layer cap could be easily constructed over the targeted portions of Areas 1A and 2.

A single-layer cap was retained for further evaluation.

<u>Multi-layer Cap</u>

A multi-layer cap is composed of a barrier clay or synthetic membrane layer, a high permeability layer for drainage, and a vegetated soil cover. A multi-layer cap that meets RCRA standards is composed of two layers of barrier and high permeability materials. The barrier clay or synthetic membrane layer prevents the vertical migration of precipitation or flood waters that might infiltrate the cap. The drainage layer diverts infiltration to the cap sides. The vegetative layer is intended to prevent erosion and enhance evapotranspiration. The cap would require periodic monitoring and maintenance to ensure structural integrity and effectiveness.

<u>Effectiveness</u>: A multi-layer cap would effectively reduce or eliminate exposure to VOCs in soil and infiltration of water through the contaminated soils.

Implementability: A multi-layer cap could be easily constructed over the targeted portions of Areas 1A and 2. The cap would extend over a large portion of the site in order to minimize the slope and control drainage. The cap design would have to address the extensive site cover and cap height so as not to significantly alter site drainage in portions of the site in close proximity to the stream channels.

A multi-layer cap was not retained for further evaluation due to the potential difficulties of implementation due to the required cap height and proximity to the stream channels.

Slurry Wall

Slurry walls are a commonly used subsurface barrier that is constructed in a vertical trench that is excavated while a slurry is poured to fill the excavation. The slurry can be composed of different mixtures of bentonite and or cement, and water. The slurry hydraulically shores the excavated trench and forms a filter cake on the trench walls to effectively prevent fluid loss into the adjacent ground. When hardened, the slurry wall is designed to contain, capture, or redirect local ground water flow. At the UOP Site, the slurry wall would be designed to prevent lateral migration of the VOC-contaminated soils with erosion and the tidal flux. (EPA, 1985) Long-term monitoring and maintenance would be required to ensure structural stability.

Effectiveness: A slurry wall could effectively control the lateral migration of contaminated soils. If coupled with a surface cover or cap, the slurry wall could contain the contaminated soils. The integrity of the slurry wall in the saturated soils and high total dissolved solids levels in the shallow aquifer would require further consideration to demonstrate effectiveness.

Implementability: A slurry wall could be constructed in Areas 1A and 2 using readily available materials and equipment. The presence of underground utility lines and subsurface drains, and concrete foundations may complicate construction.

Slurry walls were retained for further evaluation. Although implementation may be difficult, slurry walls may be effective in containing VOC-contaminated soils.

Grout Curtains

Grout curtains are installed by injecting grout under pressure into unconsolidated materials. The grout is injected at closely spaced intervals to form a continuous barrier. Difficulties in implementation and effectiveness may be encountered during installation in saturated soils, where the setting and stability of the grout are uncertain, and consolidated soils, where grout penetration may be impeded. (EPA, 1985) Long-term monitoring and maintenance are required to ensure structural stability.

Effectiveness: Under the proper conditions, grout curtains can provide an effective barrier for VOC-contaminated soils.

Implementability: Grout curtains can be constructed with readily available materials and equipment. Site conditions, including the consolidated soils, shallow ground water, and buried utilities and subsurface drains limit implementability of grout curtains.

Grout curtains are not suitable for the UOP Site and therefore were not retained for further evaluation.

Sheet Piling

Sheet piling, consisting of either wood, pre-cast concrete, or steel, can be driven into the ground to provide a continuous barrier which will contain or divert ground water. Sheet piling is generally used as a short-term measure due to long-term stability uncertainties and difficulties in sealing the sheeting. (EPA, 1985)

Effectiveness: Sheet piling could provide a short-term barrier to migration of VOCs. The long-term effectiveness of sheet piling in the saturated soils and saline ground water is uncertain.

Implementability: Equipment and materials to install sheet piling are readily available. The pilings would have to be interlocked and the seals tested prior to installation. Underground utility lines, subsurface drains, and foundations could interfere with installation.

Sheet piling was not retained for further evaluation due to the uncertainties associated with long-term effectiveness and implementability.

2.2.2 Excavation and Treatment

Excavation

Excavation and treatment or disposal of the soils could be an effective means of addressing NJDEP concerns. Soils in Areas 1A and 2 extend 10 and 13 feet to clay, respectively. The water table is a maximum of 2 feet from the surface. Therefore, the bulk of the soils in these areas is saturated. Due to the high ground water levels, the soils would have to be excavated at a 2:1 slope, or sheet piling would have to be driven around the perimeter of the excavation limits. The soils would likely be excavated in horizontal layers using conventional construction equipment such as a backhoe or a front-end loader. During excavation activities, portable pumps would be used to collect water that accumulates in the excavation area. Water collected would be stored in a holding tank for later treatment on- or off-site.

Volumes of soil to be excavated were estimated based on the results of soil sampling and analyses reported in the Remedial Investigation Report (Geraghty & Miller, 1988). In Area 1A, an estimated 40,000 square feet would be excavated to a depth of 10 feet. Incorporating the 2:1 slope required to excavate the saturated soils, the total soil volume to be excavated is 20,785 cubic yards. Of the excavated volume, approximately 3,200 cubic yards could be managed as clean soil. In Area 2, an estimated area of 1,500 square feet would be excavated to a depth of 13 feet. An estimated total volume of 3,900 cubic yards would be excavated, incorporating the additional volume attributable to excavating at a 2:1 slope. The small remediation area in Area 2 limits the feasibility of separating the clean soil during excavation. Therefore, all soils excavated from Area 2 are presumed to require remediation. Using a 20 percent factor to adjust the soil volume for expansion following excavation, a total of 22,080 cubic yards would be staged prior to remediation and allowed to drain in a prepared area. The staging area would be designed to contain runoff from the soils and divert the water that accumulates to an area where the water can be collected for treatment with the ground water collected during excavation. Approximately 3,800 cubic yards of clean soil that was excavated with the targeted soils would be staged separately. Thus, the total soil volume estimated for on-or off-site treatment or disposal is 22,080 cubic yards. Treatment and disposal options identified for the excavated soils are described below.

Treatment

Bioremediation

Bioremediation involves enhancing the microbial degradation of organic compounds into carbon dioxide and water or intermediate byproducts. Bioremediation of the VOC-contaminated soils may be accomplished in either a land treatment unit, termed "land farming", or an above-ground bioreactor, described below.

Land Farming

Land farming would involve spreading a layer of soil over a lined, impermeable unit underlain by a leachate collection system. Leachate collected may be recycled back to the soil. Nutrients and water would be added as required to optimize conditions for growth of the microbial population to accelerate biodegradation. The land farming unit can be adapted to treat VOCs by covering the soil treatment bed with a modified plastic film greenhouse, or with weighted sheeting for short-term operation. VOCs released during processing can be collected in an air pollution control system, such as carbon adsorption units.

A bench-scale treatability study would be required to determine the optimum environmental conditions for biodegradation and the design and operating criteria of the treatment system. Land farming is a well-demonstrated method for biologically treating soils and sludges containing low molecular weight organic compounds. Equipment is readily available or can be constructed as required.

Effectiveness: Land farming could effectively treat the VOCs in the UOP Site soils.

Implementability: Land farming is a well demonstrated technology, for which equipment is readily available or can be easily constructed. The large soil volumes to be treated require a large treatment area. Emission controls such as carbon adsorption or catalytic oxidation are readily available; however, controls may be difficult to implement over the expanse required for the treatment unit. Pilot-scale treatability tests will be required to determine the efficacy of the process for treatment of the soils in Areas 1 and 2A.

Land farming was not retained for further evaluation due to the extensive area required to treat the large soil volumes and the potential difficulties with emission controls.

Bioreactor

Treatment in a bioreactor involves agitation and aeration of slurried soils to maximize microbial contact with the VOCs under controlled conditions necessary to optimize microbial degradation of target contaminants. The soils would have to be screened to generate a homogeneous feed that, when mixed with water, results in the necessary slurry density. A typical soil slurry contains about 50 percent solids by weight. The slurry is mechanically agitated in the bioreactor to maintain solids suspension, with temperature controls to ensure the optimum operating temperature. Microorganisms, nutrients, oxygen and acid or alkali for pH control may be added to maintain optimum conditions. Once the desired bioremediation is complete, the treated slurry is dewatered. The residual water may require further treatment prior to disposal. The decontaminated soil is generally suitable for use as fill.

The bioreactor treatment unit can be designed to contain volatile organic emissions by directing the emissions from the closed system through a control such as an activated carbon adsorption unit that removes VOCs from the air.

A bench scale treatability study would be required to determine the optimum environmental conditions for biodegradation and the bioreactor design and operating criteria. Many biological treatment systems, such as the bioreactor described above, operate commercially. Equipment is readily available or can be constructed as required.

Effectiveness: VOCs readily biodegrade; the bioreactor is a well-demonstrated means of accelerating natural microbial degradation processes.

Implementability: The bioreactor and air emission control equipment are readily available or easily constructed. Treatability tests would be required to examine the feasibility and cost-effectiveness of bioremediation, and to determine treatment parameters. Soils would have to be treated in a closed unit to prevent the uncontrolled release of VOCs to the atmosphere.

The effectiveness of bioremediation in the bioreactor could be limited by the soil characteristics. Clayey soil is generally difficult to settle out of a slurry. Thus fines may be present in the effluent water following dewatering, possibly necessitating further treatment of the effluent water prior to discharge.

Bioremediation in a bioreactor was retained for further evaluation.

Incineration

Incinerators oxidize organic compounds in soil at temperatures ranging from 1,300 to 2,200 degrees Fahrenheit under controlled conditions. The organic compounds degrade to carbon dioxide, water vapor, sulfur dioxide, nitrogen oxides, and ash. Pollution control equipment limits air emissions, including particulates and gases. The incineration process options are identical to those presented in FS Section 2.3.3 and will not be repeated herein. (Please refer to the referenced section for details.)

<u>Effectiveness</u>: Incineration would effectively destroy VOCs.

<u>Implementability</u>: Potential difficulties with the capacity of offsite incineration facilities for incineration of contaminated soils and the availability of and permitting

onsite incinerators in northern New Jersey limit the feasibility of this alternative.

Incineration was retained for further evaluation due to its demonstrated effectiveness in destroying soils contaminated with organic compounds.

Soil Washing

Soils and sludges can be washed to separate and collect contaminants in a form that is amenable to further treatment. Generally the soil is mixed with a solution that displaces or desorbs the target compounds from the soil. The washing solution is then treated to remove the contaminants and recycled in later soil washing stages, as necessary, or discharged. Treated soil is then eligible for use as fill in excavated areas. Several vendors offer commercially available processes that rely on a variety of washing solvents. Please see FS Section 2.3.3 for a description of the primary solvents used in treating soils containing organic compounds.

<u>Effectiveness</u>: Soil washing could effectively separate the organic compounds from the soil matrix.

<u>Implementability</u>: The implementability of this alternative would be dependent on materials handling and the effectiveness of the selected washing solvent with silts and clays. Clay can impede desorption. Repeated soil washings may be required to treat the soils in Areas 1A and 2. The washing solution requires further treatment.

Washing will be retained for further evaluation using the same process retained in FS Section 2.3.3 - the "Basic Extractive

Sludge Treatment (B.E.S.T.[R]) process. Other soil washing processes are available and may be selected during remedial design.

Solidification

Solidification involves mixing the contaminated soil with stabilizing agents that result in the production of a continuous stabilized mass or treated block of soil. This process effects a chemical or physical reduction in the mobility of hazardous constituents by binding the constituents into a low permeability solid that resists leaching.

Stabilizing agents can be inorganic or organic in nature, with the mechanism of binding dependent on whether the agent is cement-based, pozzolanic or silicate-based, thermoplastic-based or organic polymer-based. One agent may be used in conjunction with another to enhance the properties of the solid product.

If the soil is not relatively homogeneous, then screening or shredding may be required to ensure effective binding and immobilization within the matrix. Following screening, the soil is mixed with the stabilizing agent, with water added as required, and the resultant mass is allowed to cure.

Bench-scale treatability tests are required to determine the most effective stabilizing agents, waste-to-additive ratios, mixing and curing conditions.

Solidification of VOCs has not been demonstrated. VOCs often volatilize during excavation, mixing or curing because of the agitation and heat of hydration (EPA, 1988 and EPA, 1989). In addition, many organic binder technologies require preheating as a part of processing which causes further volatilization (EPA, 1989). An EPA SITE demonstration project reported that volatile organics were primarily released to the air during mixing with the stabilizer (EPA, March 1989).

Several vendors offer solidification processes. All processes rely on proprietary reagent blends and/or other additives such as pozzolanic and cement-based materials.

Effectiveness: No data were found to indicate that solidification is an effective treatment technology for VOC-contaminated soils. VOCs would volatilize during heating and mixing of the contaminated soil with the stabilizing agents. Percentages of the VOCs present may be trapped within the inorganic matrix in the case of cement-based and pozzolanic processing (EPA,1989), volatilization of a majority of the volatile compounds would be expected to occur.

Implementability: Solidification could be easily implemented using readily available materials and equipment. The process is well-demonstrated and many vendors offer the technology commercially.

Solidification was not retained for further evaluation because it has not been proven effective for treatment of VOC-contaminated soils.

Thermal Separation

Thermal separation processes are designed to separate volatile and semi-volatile organic compounds from soils based on the compound's volatility and the unit's operating temperature.

Thermal desorption and steam stripping were described in FS Section 3.3.3; these processes are screened below.

Effectiveness: Both thermal desorption and steam stripping could effectively separate the VOCs from the soil.

Implementability: Several vendors supply demonstrated mobile thermal desorption units; there are no known commercially available steam stripping units. Bench-scale testing would be required to ensure effective air pollution controls. The condensate and or vapors collected would require further treatment.

Thermal desorption will be retained for further evaluation using the X*TRAX[R] unit offered by Chemical Waste Management (CWM). Other thermal desorption units may be selected during remedial design.

Vacuum Extraction

Vacuum extraction refers to the process of stripping volatile compounds from the soil. Vacuum extraction would be carried out by excavating and passively dewatering the soil. The soil is placed on an impermeable liner that may have a leachate collection system in place to collect entrained water that drains from the soil mass. Perforated or slotted pipes are placed within the pile, and individual extraction vents are connected through a manifold to an exhaust blower which would pull air through the soil. Air may be injected into the soil in order to increase the air flow through the soil and improve the system's performance.

The vacuum extraction process would direct the VOC emissions from the exhaust blower to a control such as an vapor-phase activated carbon adsorption unit or a catalytic burner, preceded by a water trap to prevent water from entering the downstream units.

Bench- and pilot-scale studies would be required prior to full-scale implementation to determine the effectiveness of vacuum extraction of excavated soil under site conditions.

Effectiveness: Vacuum extraction may be effective in removing VOCs from the soils. However, bench- and pilot-scale testing would be required to determine the efficacy of this technology for VOC removal from the UOP Site soils.

Implementability: Vacuum extraction equipment and air emissions control equipment are readily available or easily constructed. The soil must be sufficiently dewatered to effectively extract VOCs.

Vacuum extraction was retained for further evaluation.

2.2.3 Excavation and Disposal

Onsite

Onsite disposal of excavated soils and debris would have to comply with both the Federal Resource Conservation and Recovery Act (RCRA) and State of New Jersey hazardous waste facility requirements. As described in FS Section 2.3.4, the landfill would have to be designed to minimize washout of floodwaters, or special contingency arrangements maintained for removal of the materials in the event of a flood (40 CFR 264). The landfill would require continued operation and monitoring of leachate collection and detection systems. Additional ground water monitoring would also be required.

Effectiveness: With proper engineering and maintenance, an onsite permittable disposal facility should effectively contain, but will not eliminate, the VOC-contaminated soils.

Implementability: Site conditions, such as the shallow depth to ground water, the poor wetland drainage characteristics, and location in the 100-year floodplain, and applicable regulations limit the feasibility of constructing a permittable landfill onsite.

Disposal in an onsite landfill was not retained for further evaluation due to limitations posed by site conditions and applicable regulations.

Offsite

Excavated material could be dewatered and transported offsite for treatment or disposal in a landfill. Section 121(d)(3) of SARA requires that offsite disposal of hazardous substances, pollutants or contaminants occur at a facility in compliance with Section 3004 and 3005 of RCRA and with applicable State requirements. The receiving facility must meet two requirements: (1) the disposal unit must not be releasing contaminants to ground water, surface water, or soil; and (2) releases from other units at the facility must be controlled by a corrective action program under RCRA. Additional soil sampling and analyses would be required to characterize the waste prior to acceptance by a licensed facility.

Effectiveness: Offsite disposal in a landfill would not eliminate the VOCs of concern to NJDEP at the UOP Site.

Implementability: Offsite disposal would require excavating and dewatering the saturated soil. Commercial disposal facilities are readily available. The soils have to be managed in compliance with RCRA Sections 3004 and 3005 per SARA 121(d). Air emission controls may be required during excavation and dewatering activities.

Offsite disposal of excavated soils was retained for further evaluation.

2.2.4 In-situ Treatment

Bioremediation

In-situ bioremediation refers to the enhancement of the natural microbial breakdown of organic compounds, ultimately into carbon dioxide and water in an aerobic system, or methane and carbon dioxide in an anaerobic system. The addition of nutrients and oxygen in an aerobic system enhances natural degradation processes. The targeted treatment area should be relatively homogeneous to ensure that necessary nutrients and oxygen are thoroughly distributed through the target area. The enhancement media must be circulated hydraulically through the substrata using either injection wells, well points, or trenches to ensure the necessary contact between the affected medium and the nutrients and microorganisms. In-situ bioremediation can effectively treat both the saturated and unsaturated zones under the proper site conditions.

Effectiveness: Most VOCs present in the UOP Site soils are readily biodegradable. The effectiveness of in-situ biodegradation would be limited by soil permeability and variable ground water flows which make uniform distribution of enhancement media through the affected areas difficult.

Implementability: As stated above, implementation of this option requires installation of gradient controls and a hydraulic delivery system. The option requires that the Site hydrogeology allow for sufficient distribution of nutrients. The variability of the soil matrix would impede delivery of enrichment media. The low to moderate permeability of the substrata and diverse ground water mounds and divides would further complicate delivery. Pneumatic fracturing is an emerging technology which increases soil permeability in localized areas. However, localized increases in permeability would not ensure uniform distribution of enrichment media. Practical long-term operation of an in-situ bioremediation system in low permeability soils is uncertain.

In-situ bioremediation will not be retained for further evaluation due to implementation difficulties and uncertainties associated with effectiveness in the UOP Site soils.

Solidification

Solidification of the soil in-situ would be performed in the same manner as the solidification process described previously. The additive or binding agents may be injected into the remediation area through mixing augers or rotors. Some dewatering may be required to facilitate in-situ operations. The ground water, however, would not be expected to interfere with solidification and curing.

Effectiveness: Solidification has not been proven to be effective for immobilizing VOCs. The VOCs would likely volatile during soil agitation. In addition, the long-term effectiveness of solidification in wetland conditions is uncertain.

Implementability: In-situ solidification could be implemented with readily available materials and equipment. Buried utilities, subsurface drains, and building foundations may interfere with solidification activities. Minimal dewatering may be required to facilitate solidification. However, solidification of saturated soils would require additional additives. The additional additives required to stabilize saturated soils, would be expected to result in a 50 percent increase in the volume of treated soils. Thus, in-situ solidification would generate a mound of treated soils in the targeted remediation areas.

In-situ solidification will not be retained for further evaluation because solidification has not been demonstrated to effectively treat VOC-contaminated soils and due to the potential implementation difficulties.

Vacuum Extraction

In-situ vacuum extraction refers to the process of stripping volatile compounds from the subsurface soils in place. Air is extracted from contaminated soils through a series of wells. Individual extraction wells are connected through a manifold to an exhaust blower that pulls air through the soil. Air may be mechanically injected into the soil in order to increase the air flow through the soil and improve the system's performance.

In-situ vacuum extraction would treat VOC emissions by directing the emissions from the exhaust blower to a control such as a vapor-phase activated carbon adsorption unit or a catalytic oxidation unit. The control unit would be preceded by a water trap to prevent water from entering the emissions control unit.

The effectiveness of vacuum extraction depends on the volatility of compounds in the soil, the rate of air circulation through the soil, and the soil permeability and moisture content. Treatment of saturated soils is not efficient because of mass transfer limitations. Therefore, dewatering is required. Pilot-scale studies would be required prior to full-scale implementation.

<u>Effectiveness</u>: In-situ vacuum extraction may be effective for the soils in Areas 1 and 2A. Effectiveness depends in large part on soil permeability and moisture. The soil will need to be dewatered, as excess moisture in the soil limits the effectiveness of the VOC extraction process.

<u>Implementability</u>: In-situ vacuum extraction of VOCs in soils has been implemented successfully at a number of sites. The vacuum extraction equipment and air emissions control equipment are readily available or easily constructed. Tests would be required to examine the feasibility and cost-effectiveness of vacuum extraction. Implementation of treatment would be limited by the characteristics of the soil, with soil type, air permeability, contaminant type and concentration, and moisture content being of concern. Pneumatic fracturing is

an innovative technology that is designed to increase soil permeability. Pneumatic fracturing may increase the soil permeability sufficiently to make vacuum extraction effective, once soils are dewatered.

In-situ vacuum extraction was retained for further evaluation for treatment of soils.

Vitrification

In-situ vitrification thermally converts contaminated soils into a chemically inert glass. The process was developed to stabilize radionuclide-contaminated soils by melting them into a durable glass and crystalline form. Vitrification is accomplished by inserting electrodes into the soils in a square array. A mixture of graphite and glass frit is placed between the electrodes to create a pathway for the electric current. Dissipation of energy through the starter materials produces temperatures in excess of 3,000 degrees Fahrenheit, sufficient to melt a layer of soils. The molten zone extends downward through the soils, following the conductive path. Organic materials pyrolyze, diffuse to the surface, and combust. Off-gases are collected, monitored, and treated.

Effectiveness: Vitrification would likely volatilize the majority of VOCs in the soils and immobilize or destroy only a fraction of the total VOC concentration. Air emission controls would be required to ensure that volatilized compounds were not released to the atmosphere during treatment. Vitrification could not be implemented unless the ground water table was lowered to a depth sufficient to insert the electrodes into the surface soils. Vitrification has not been well demonstrated under conditions analogous to the UOP Site.

Implementability: Vitrification is an energy and labor intensive technology with a level of sophistication that requires highly trained operators. The shallow ground water substantially complicates, if not prevents, the implementation of this option.

In-situ vitrification will not be retained for further evaluation due to the uncertainties associated with the effectiveness on VOC-contaminated soils and the implementation difficulties described above.

2.3 Summary of Screened Remedial Technologies

The technologies retained in the technology screening are listed in Table 2-4. As shown, the single-layer cap and slurry walls were the only containment measures retained given the conditions of Areas 1A and 2. Individually neither the single-layer cap nor the slurry wall achieves remediation goals. In combination, the retained containment measures could effectively prevent migration of the VOCs. Treatment technologies retained include: bioremediation in a bioreactor, on- or off-site incineration, soil washing, thermal desorption, and vacuum extraction. On-site disposal was not retained for further evaluation due to site conditions. Off-site disposal was retained. Most of the in-situ technologies were not retained for many of the same reasons that these technologies were not retained for Area 5 soils. Site conditions pose difficulties in implementing in-situ technologies; implementation difficulties often transcend to uncertainties with effectiveness. Vacuum

TABLE 2-4
UOP SITE
EAST RUTHERFORD, NJ
SUMMARY OF SCREENED REMEDIAL TECHNOLOGIES
FOR VOC-CONTAMINATED SOILS

GENERAL RESPONSE MEASURE	RETAINED TECHNOLOGY	PROCESS OPTION RETAINED (where appropriate)
No Action/ Institutional Controls		
Containment	Single-layer Cap	
	Slurry Wall	
Treatment of Excavated Soil	Bioremediation	Bioreactor
	Incineration	Rotary Kiln Shirco Infrared Conventional Fluidized Bed Circulating Fluidized Bed Combuster Advanced Electric Reactor
	Soil Washing	Solvent Extraction
	Thermal Separation	Thermal Desorption
	Vacuum Extraction	
Disposal of Excavated Soils	Landfill	Offsite
In-Situ Treatment	Vacuum Extraction	

extraction may be feasible if combined with pneumatic fracturing and dewatering and was therefore retained.

Based on the technologies retained through the screening process, alternatives were developed for detailed evaluation. The alternatives developed to address the VOC-contaminated soils in Areas 1A and 2 are presented and evaluated in the following section.

3

3. DEVELOPMENT AND DETAILED EVALUATION OF ALTERNATIVES FOR VOC-CONTAMINATED SOILS

3.1 Introduction

The technologies and process options that were retained through the technology screening process were developed into alternatives to address the VOC-contaminated soils in Areas 1A and 2. The alternatives were not screened, consistent with EPA guidance as described in FS Section 3.1. This section presents and evaluates the alternatives according to the seven EPA criteria and the criteria outlined in the Administrative Consent Order (ACO). The combined EPA and ACO criteria were presented in Table 4-1 of the FS. Alternatives are presented by general response measure below.

3.2 No Action/Institutional Controls

Description

Under the no action alternative, the soils in Areas 1A and 2 would not be disturbed. If deemed necessary, institutional controls could be implemented to restrict land use in these portions of the Site or these areas could be fenced to restrict access. Generally, the no action alternative is appropriate when the potential endangerment is negligible or if implementation of a remedial action would result in a greater potential risk than no action. The VOC-contaminated soils do not presently pose a human health or environmental risk, as determined in the risk assessment (ENSR, June 1989; November 1989). Implementation of a remedial action would pose a short-term risk of exposure to benzene and other VOCs in the soils. Short-term risks could be minimized but not prevented with engineering controls.

Evaluation

Overall Protection of Human Health and the Environment

The VOCs in Areas 1A and 2 do not presently pose a risk to human health and the environment. Therefore, the no action alternative protects human health and the environment.

Compliance with ARARs

Action-specific ARARs identified for the VOC-contaminated soils are presented in Table 3-1. The no action alternative complies with ARARs identified for the UOP Site.

Long-term Effectiveness and Permanence

The no action alternative would not permanently alter site conditions. With time, the VOCs would degrade and disperse.

Short-term Effectiveness

There would be no change in Site conditions in the short-term. However, there would be no short-term exposure risks associated with the no action alternative that would be associated with action alternatives.

Reduction of Toxicity, Mobility, and Volume through Treatment

The no action alternative would neither reduce the toxicity, the mobility, nor the volume of VOCs in the soil. The VOCs

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
No Action/ Institutional Controls	Five year review [SARA 121(c)] Remedial actions which leave hazardous substances at a site must be reviewed every five years.	
Containment	Five year review [SARA 121(c)] Remedial actions which leave hazardous substances at a site must be reviewed every five years. Occupational Safety and Health Standards [20 CFR 1910, 1926, 1904] Worker health and safety requirements	
		Wetlands Act [NJSA 13:9a-1 et seq.] Regulates any construction activity in coastal or tidal wetlands mapped or delineated pursuant to the Act as outlined in NJAC 7:7 below. Coastal Permit Program Rules [NJAC 7:7] Type B permits required to dredge, fill, excavate, or alter marsh contours. Hackensack Meadowlands Reclamation and Development Act [NJSA 13:17-1 et seq.] Regulates discharge of dredge and fill materials in the Hackensack area, supersedes Freshwater Wetlands Protection Act Regulations

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
Containment (Continued)		Rules on Coastal Resources and Development [NJAC 7:7E-1.1] Special area protection, including floodplains. Policies to protect wet soils and high permeability moist soils. Stream Encroachment [NJAC 7:13] Permits required for construction, installation, or alteration of any structure or permanent fill along, in, or across the channel or flood plain of any stream. NJ Water Pollution Control [NJAC 7:14A-1 et seq] Regulates discharges to ground and surface waters through NJ Pollutant Discharge Elimination System (NJPDES) permits. Noise Control [NJAC 7:29A] Permittees under NJ laws shall employ appropriate measures to minimize noise.
Soil Excavation and Treatment	Occupational Safety and Health Standards [20 CFR 1910, 1926, 1904] Worker health and safety requirements TSCA regulations for storage and treatment of PCB-contaminated soil [40 CFR 761.60(a)(4)] Soils containing 50 ppm or greater PCBs must be stored in compliance with 40 CFR 761.65	

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
Soil Excavation and Treatment (Continued)	Non-liquids containing 50 ppm or greater PCBs must be disposed of in an incinerator or a landfill that complies with 40 CFR 761.70 or 40 CFR 761.75, respectively per 40 CFR 761.60. Dredged material can also be disposed of by alternate methods upon EPA approval per (40 CFR 761.60(a)(E)(5)(iii))	
	Liquids containing 50 ppm or greater PCB concentrations shall be disposed of in an incinerator which complies with 40 CFR 761.70 or in a high efficiency boiler per 40 CFR 761.60.	
	Liquid hazardous wastes containing 50 ppm or greater PCB concentrations are prohibited from land diposal per 40 CFR 268.32	
	National Emission Standards [40 CFR 61]	NJ abides by federal NESHAPs
	Particulate Emission Standards [40 CFR 50.6] Requires particulate emission controls	
		Air Pollution Control Incinerators [NJAC 7:27-11] Particulate & smoke emission stds.
		Ambient Air Quality Standards [NJAC 7:27-13] Regulates suspended particulate matter, sulfur dioxide, carbon monoxide, ozone, lead, and nitrogen dioxide.

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
Soil Excavation and Treatment (Continued)		Control and Prohibition of Air Pollution by Volatile Organic Substances [NJAC 7:27-16] Regulates emissions of ten volatile organics
		Control and Prohibition of Air Pollution by Toxic Substances [NJAC 7:27-17] Regulates emissions of total volatile organic compounds.
		Wetlands Act [NJSA 13:9a-1 et seq.] Regulates any construction activity in coastal or tidal wetlands mapped or delineated pursuent to the Act as outlined in NJAC 7:7 below.
		Coastal Permit Program Rules [NJAC 7:7] Type B permits required to dredge, fill, excavate, or alter marsh contours.
		Hackensack Meadowlands Reclamation and Development Act [NJSA 13:17-1 et seq.] Regulates discharge of dredge and fill materials in the Hackensack area, supersedes Freshwater Wetlands Protection Act Regulations
		Rules on Coastal Resources and Development [NJAC 7:7E-1.1] Special area protection, including floodplains. Policies to protect wet soils and high permeability moist soils.

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
Soil Excavation and Treatment (Continued)		Stream Encroachment [NJAC 7:13] Permits required for construction, installation, or alteration of any structure or permanent fill along, in, or across the channel or flood plain of any stream.
		NJ Water Pollution Control [NJAC 7:14A-1 et seq] Regulates discharges to ground and surface waters through NJ Pollutant Discharge Elimination System (NJPDES) permits.
		Noise Control [NJAC 7:29A] Permittees under NJ laws shall employ appropriate measures to minimize noise.
Excavation and Offsite Disposal	Occupational Safety and Health Standards [20 CFR 1910, 1926, 1904] Site worker health and safety requirements	
	TSCA Transportation and Disposal Restrictions [40 CFR 761.60(a)(4)] PCB-contaminated soil must be transported and disposed of in compliance with TSCA. Disposal requirements are identical to those presented above. Transport of PCB-contaminated soils and liquids must be transported in containers which comply with DOT specifications per 40 CFR 761.65(c)(6).	
	National Emission Standards [40 CFR 61]	NJ abides by federal NESHAPs

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
Excavation and Offsite Disposal (Continued)	Particulate Emission Standards [40 CFR 50.6] Requires limiting concentration of particulate matter allowed in air.	Control and Prohibition of Air Pollution by Volatile Organic Substances [NJAC 7:27-16] Regulates emissions of ten volatile organics.
		Control and Prohibition of Air Pollution by Toxic Substances [NJAC 7:27-17] Regulates emissions of total volatile organic compounds.
		Wetlands Act [NJSA 13:9a-1 et seq.] Regulates any construction activity in coastal or tidal wetlands mapped or delineated pursuant to the Act as outlined in NJAC 7:7 below.
		Coastal Permit Program Rules [NJAC 7:7] Type B permits required to dredge, fill, excavate, or alter marsh contours.
		Hackensack Meadowlands Reclamation and Development Act [NJSA 13:17-1 et seq.] Regulates discharge of dredge and fill materials in the Hackensack area, supersedes Freshwater Wetlands Protection Act Regulations
		Rules on Coastal Resources and Development [NJAC 7:7E-1.1] Special area protection, including floodplains. Policies to protect wet soils and high permeability moist soils.

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
Excavation and Offsite Disposal (Continued)		Stream Encroachment [NJAC 7:13] Permits required for construction, installation, or alteration of any structure or permanent fill along, in, or across the channel or flood plain of any stream. NJ Water Pollution Control [NJAC 7:14A-1 et seq] Regulates discharges to ground and surface waters through NJ Pollutant Discharge Elimination System (NJPDES) permits. Noise Control [NJAC 7:29A] Permittees under NJ laws shall employ appropriate measures to minimize noise.
	Requirements for offsite disposal of waste from a Superfund site [SARA 121(d)(3)] Hazardous substances, pollutants, or contaminants removed during a remedial action must be transferred to a facility that meets RCRA performance stds.	
In-Situ Treatment	Occupational Safety and Health Standards [20 CFR 1910, 1926, 1904] Worker health and safety requirements Liquids containing 50 ppm or greater PCB concentrations shall be disposed of in an incinerator which complies with 40 CFR 761.70 or in a high efficiency boiler per 40 CFR 761.60.	

TABLE 3-1
ACTION SPECIFIC ARARS
VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
In-Situ Treatment (Continued)	Liquid hazardous wastes containing 50 ppm or greater PCB concentrations are prohibited from land diposal per 40 CFR 268.32	
		Control and Prohibition of Air Pollution by Volatile Organic Substances [NJAC 7:27-16] Regulates emissions of ten volatile organics.
		Control and Prohibition of Air Pollution by Toxic Substances [NJAC 7:27-17] Regulates emissions of total volatile organic compounds.
		Wetlands Act [NJSA 13:9a-1 et seq.] Regulates any construction activity in coastal or tidal wetlands mapped or delineated pursuant to the Act as outlined in NJAC 7:7 below.
		Coastal Permit Program Rules [NJAC 7:7] Type B permits required to dredge, fill, excavate, or alter marsh contours.
		Hackensack Meadowlands Reclamation and Development Act [NJSA 13:17-1 et seq.] Regulates discharge of dredge and fill materials in the Hackensack area, supersedes Freshwater Wetlands Protection Act Regulations

TABLE 3-1

ACTION SPECIFIC ARARS

VOC-CONTAMINATED SOILS - AREAS 1A AND 2

Response Measure	Federal ARARs	State ARARs
In-Situ Treatment (Continued)		Rules on Coastal Resources and Development [NJAC 7:7E-1.1] Special area protection, including floodplains. Policies to protect wet soils and high permeability moist soils.
		NJ Water Pollution Control [NJAC 7:14A-1 et seq] Regulates discharges to ground and surface waters through NJ Pollutant Discharge Elimination System (NJPDES) permits.
		Noise Control [NJAC 7:29A] Permittees under NJ laws shall employ appropriate measures to minimize noise.

would naturally degrade with time.

Implementability

There are no immediate actions required under the no action alternative. Periodically the soils could be monitored to ensure that, if the VOCs posed a risk, actions would be taken.

Cost

The cost associated with the no action alternative is identical to the cost for no action in Area 5. An estimated $40,000 would be required to perform long-term monitoring and maintenance of the Site, as shown in Table 3-2 and Appendix A.

Summary

The no action alternative is appropriate for the soils that contain VOCs. The risk assessment concluded that the VOCs did not pose a human health or an environmental risk. Subsequent modeling evaluated the impacts from upland erosion and ground water discharge on the stream channels, as described in FS Section 1.3.2 and Appendix A. The modeling concluded that the VOCs were transported to the stream sediments primarily through ground water discharge. Predicted surface water concentrations resulting from ground water discharge were well below marine ambient water quality criteria for acute and chronic toxicity and species-specific toxicological benchmarks for the indicator species that were evaluated in the ecological risk assessment.

In addition, to protecting human health and the environment, the no action alternative meets ARARs. The site would be monitored at 5-year intervals, consistent with SARA. If changes

Table 3-2
UOP Site – Area 1A & 2
Summary of Total Present Worth Costs
of Remediation Alternatives

Alternative	Total Cost
No Action	$40,000
Containment	
Asphalt Cap	$1,500,000
Concrete Cap	$1,600,000
Excavation and Treatment	
Bioremediation	$5,400,000
Incineration	
Onsite	$11,900,000
Offsite	$103,900,000
Soil Washing	$10,100,000
Thermal Desorption	$11,600,000
Vacuum Extraction	$4,900,000
Offsite Landfill Disposal	$13,900,000
In–situ Vacuum Extraction	$3,000,000

in Site conditions dictate, further action would be taken. An estimated $40,000 would be incurred in long-term monitoring and maintenance of Areas 1A and 2.

3.3 Containment - Single-layer Cap and Slurry Wall

Description

Under this alternative a single-layer cap of either asphalt or concrete could be constructed over the targeted portions of Areas 1A and 2 to inhibit volatilization of VOCs from and infiltration of water through the soils. In addition, a slurry wall would be constructed around the perimeter of each area and extend to the barrier clay to prevent lateral migration of the VOC-contaminated soils. Wellpoints would be required to manage water that accumulates in the containment area.

The single-layer cap would be constructed to meet roadway specifications in the manner described in Section 4.2.2. of the FS. The areas would be mowed and any large debris removed prior to cap construction. Backfill would be spread, compacted, and graded to form a maximum 2 percent slope for drainage from the cap. After grading, a gravel (6 inches) and stone (1 foot) foundation would be installed. A minimum of a 4-inch layer of either asphalt or concrete would be spread or poured over the foundation.

The slurry wall would be constructed to minimize interference with underground utilities and subsurface drains. The slurry wall could be constructed of a mixture of bentonite and or cement, and water. A soil-bentonite slurry was selected for evaluation in this FS due to the construction versatility and cost-effectiveness. Other mixtures may be selected during remedial design.

Standard construction equipment would be used to excavate the trench and mix the slurry and the backfill. The slurry is introduced as the trench is excavated, shoring the trench and caking on the trench walls. When a sufficient length has been excavated, backfill is lowered into the base of the trench until the sloped backfill meets the surface. The backfill, composed of soil and slurry, is controlled during mixing and wall construction. The backfill must flow freely into the trench but neither (1) flow into the remediation area, (2) fail to displace the slurry initially poured, nor (3) require that a large portion of the trench be kept open (EPA, 1985).

Wellpoints would be installed to recover water that collects during cap and slurry wall construction, and maintained to manage any water that accumulates within the contained area. Well points are specially designed well screens that range from 1.5 to 3 inches in diameter. The wellpoints are installed in oversize boreholes where the annular space is filled with sand to increase the effective diameter of the well. The wellpoints are generally closely spaced, connected to a header pipe, and pumped by vacuum or suction. The pump can be wired to a level sensor to activate the pump when the water reached a preestablished level. The water would be pumped to a holding tank from which it would either be diverted to an onsite treatment unit or pumped to a tanker truck for offsite treatment. This FS assumes an estimated five wells would be installed in Area 1A and two wells would be installed in Area 2. More or fewer wells may be determined to be appropriate during remedial design.

The containment area would be inspected monthly to ensure the structural stability of the cap and slurry wall, and proper operation of the well points.

Evaluation

Overall Protection of Human Health and the Environment

A single-layer cap and slurry wall should protect human health and the environment. Construction activities may pose a short-term human health risk from exposure to the VOCs and a short-term increase in environmental risk with the potential increase in mobility. These risks could be minimized, but not prevented, with engineering controls. The VOCs presently pose neither human health nor environmental risks. Therefore, containment would not decrease the overall protection of human health and the environment.

Compliance with ARARs

The action-specific ARARs identified for the containment alternative are listed in Table 3-1. A Type B wetlands permit and a stream encroachment permit would be required. If collected water is treated onsite, a NJPDES permit would be required to discharge treated water to the stream channels. These permits could be obtained within a reasonable timeframe. Once obtained, the containment alternative would comply with ARARs.

Long-term Effectiveness and Permanence

The single-layer cap and slurry wall, if well-maintained, could permanently contain the VOC-contaminated soils.

Reduction of Toxicity, Mobility, and Volume through Treatment

Containment would neither reduce the toxicity, the mobility, nor the volume of VOC-contaminated soils.

Short-term Effectiveness

As stated above, construction activities would pose short-term risks to human health and the environment. Construction is estimated to require approximately 31 months, as shown in Table 3-3. Risks could be minimized, but not eliminated, during the construction period.

Implementability

The single-layer cap and slurry wall could be constructed with readily available materials and equipment. Underground utilities and subsurface drains, if encountered, would seriously interfere with slurry wall construction. The shallow ground water would likely reduce the construction rate as water would accumulate in the trench and may retard the slurry curing rate.

Cost

The containment alternative is estimated to cost $1.5 million to construct an asphalt cap and $1.6 million to construct a concrete cap, as shown in Table 3-2 and Appendix A.

Summary

The VOC-contaminated soils could be contained within a single-layer asphalt or concrete cap and slurry wall. The containment alternative would result in a reduction in the

Table 3-3
VOCs in Soils
Estimated Time Requirements for Remediation Alternatives

Activity	Cap and Containment	Bioremediation	Onsite Incineration	Offsite Incineration	Soil Washing	Thermal Desorption	Ex-Situ Vacuum Extr.	Offsite Disposal	In-Situ Vacuum Extr.
	Time in Months								
Remedial Design Workplan	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Pre-Design Studies	2	5	2	2	4	3	3	2	12
Pre-Design Report	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Remedial Design	5	7	7	4	7	7	7	4	7
Permitting	9	9	24	9	9	12	12	6	12
Implementation									
Mobilization	1	1	2	1	2	2	1	1	1
Site Prep/Construction	1	1	1	1	2	1	1	1	2
Operation	2	7	12	36	11	12	24	2	24
Demobilization	1	1	1	1	2	1	1	1	1
Closeout	3	3	3	3	3	3	3	3	3
Total Time to Completion	31	41	59	64	47	48	59	27	69

overall protection of human health and the environment because of short-term exposure potential. Permits could likely be obtained to comply with ARARs and implement the alternative. Long-term effectiveness is dependent on maintenance. Containment provides no permanent reduction in the VOCs present. In the short-term, construction would pose risks to workers and the environment. Site conditions, including the shallow depth to ground water and the unknown locations of underground utilities and subsurface drains, pose potentially serious implementability problems. Implementation is estimated to require 31 months and cost $1.5 and $1.6 million for an asphalt and a concrete cap, respectively.

3.4 Excavation and Treatment

3.4.1 Bioremediation

Description

Bioremediation involves enhancing the microbial breakdown of organic compounds into carbon dioxide and water, or intermediate byproducts. Biodegradation is enhanced in a bioreactor by controlling the conditions, such as temperature, pH, and nutrient and oxygen concentrations, to optimize growth of the desired microbial population. Generally the soils must be mixed with water to form the desired density slurry. A typical soil slurry contains a minimum of 50 percent solids by weight. In this case, the ground water collected during excavation and passive dewatering during staging would be combined with the excavated soil for treatment. In the unit, the slurry is mechanically agitated to keep solids suspended in solution and often aerated to maximize contact between the microorganisms and the contaminated surfaces. Following biological treatment, the slurry is dewatered. The residual water may require further treatment prior to disposal. The decontaminated soil could be used as fill.

The process can be adapted to control VOC emissions by enclosing the unit and directing the emissions from the closed system through a separate treatment unit, such as an activated carbon adsorption unit that removes VOCs that were not biodegraded.

Aside from the biodegradability of compounds present in the soil, other limiting factors include the presence of inhibiting compounds and operating temperature. Heavy metals and chlorides may inhibit microbial metabolism because of their toxicity. Pretreatment may be required to remove problem compounds. A bench-scale treatability study would be required prior to implementation, to determine the biodegradability of the soil constituents, the optimum environmental conditions for biodegradation, and the presence of toxic compounds.

Bioreactors are commercially available and have been applied successfully in other soil treatment applications. Equipment is readily available or can be constructed as required. The soils must be screened, and crushed or shredded if necessary, to generate a homogeneous feed with a maximum particle size of less one-half inch. It is assumed for the purpose of this FS that the treated soils will be suitable for use as backfill onsite.

Evaluation

Protection of Human Health and the Environment

Bioremediation would effectively protect human health and the environment by eventually degrading the VOCs to innocuous compounds - carbon dioxide and water. Emission controls would be required to prevent the release of VOCs prior to degradation. In the short term, potential risk from exposure to VOCs exists during excavation and handling, but can be controlled, but not eliminated, by following a health and safety plan.

Compliance with ARARS

The action-specific ARARS are presented in Table 3-1. Biological treatment in a closed system would comply with ARARs, though a NJPDES permit would be required to discharge or otherwise dispose of the water produced when the soil slurry is dewatered. Air emissions during treatment must be controlled to comply with state and Federal regulations.

Long-term Effectiveness and Permanence

Biological treatment is expected to permanently reduce the concentration of VOCs in the soil. Most of the VOCs are by nature readily biodegradable.

Reduction of Toxicity, Mobility and Volume Through Treatment

The toxicity and volume of VOCs in the soil would be reduced by biological treatment due to degradation of the biodegradable compounds in the soil to carbon dioxide and water, or intermediate by-products. A substantial fraction of the volatile compounds will be removed through volatilization during aeration in the bioreactor, and will be captured by the air emissions control unit. In the case of activated carbon adsorption, this will reduce the mobility and volume of the VOCs. The activated carbon would require further treatment.

Short-term Effectiveness

Short-term risks associated with the soil excavation and handling exist, as site activities would pose exposure risks to workers. The volatile nature of the contaminants presents the risk of inhalation. Risks would be minimized by adherence to a health and safety plan. During treatment, risks are minimized by the presence of air emission controls such as activated carbon adsorption on the closed bioreactor.

Onsite biological treatment would require an estimated 8 to 10 months to implement, inclusive of the bench scale treatability study, as shown in Table 3-3. This estimate assumes that the findings of the treatability study confirm the effectiveness of bioremediation of the soil, and that site activities would proceed with minimal interruptions from weather, contractor and other administrative delays.

Implementability

Bioremediation has been successfully implemented for the remediation of sites contaminated with organics. Bioremediation would require standard construction equipment to excavate the contaminated soil. Soils must be screened to remove large debris in order to produce a homogenized soil slurry. The bioreactor equipment and air emissions control equipment are readily available or easily constructed. Treatability tests would be required to examine the feasibility and cost-effectiveness of bioremediation, and to determine treatment parameters.

Implementation would be limited by the consistency of the soil. Clayey soil is difficult to settle out of a slurry, resulting in fines in the effluent water after dewatering, possibly requiring further treatment prior to discharge.

Cost

Bioremediation in a bioreactor is estimated to cost $5.4 million, as shown in Table 3-2 and Appendix A.

Summary

Bioremediation, if found to be effective following the bench-scale test, would destroy the VOCs in the soil. Short-term risks during excavation and materials handling phases could be addressed by the health and safety plan. Engineering controls such as carbon adsorption for vapor phase control would be implemented during treatment. Bench- and pilot-scale tests would be required to determine the efficacy of the process for treatment of the soils in Areas 1 and 2A. If selected, this remedial alternative would take an estimated total of 41 months and $5.4 million to implement.

3.4.2 Incineration

Incineration units are designed to destroy organic compounds at elevated temperatures and pressures. The incineration units are equipped with air pollution control systems to contain particulates and combustion products. Please see FS Section 4.2.3 for a detailed description of incineration processes. For the purpose of this Addendum, the incineration processes evaluated in the FS, the circulating fluidized bed combuster (CFC) for onsite treatment and the rotary kiln incinerator for offsite treatment, are assumed to provide sufficient bases for comparison of the alternative evaluated herein. On- and off-site incineration alternatives are evaluated below.

Onsite Incineration

Description

Onsite incineration was evaluated based on the CFC offered by Ogden Environmental Services (OES). Other incineration processes may be selected for the VOC-contaminated soils during remedial design. The CFC uses a high velocity air stream to create a turbulent combustion zone allowing for greater destruction of hazardous substances and longer retention of resultant acid gases. Please see the CFC description in FS Section 4.2.3 for details.

Evaluation

Protection of Public Health and the Environment

Onsite incineration would destroy the VOCs. A trial burn would be required to ensure that emissions levels are acceptable. In the short-term, site activities, including excavation and materials handling, may pose human health risks from the VOCs as well as potential ecological effects from erosion and runoff. The human health and ecological risks could be minimized by adhering to a health and safety plan and with engineering controls.

Compliance with ARARs

Table 3-1 lists the action specific ARARs identified. A Type B permit would be required to excavate the soils. Bench-scale tests would be necessary to determine whether emissions would be within NESHAPs and state VOC emission requirements and to determine the disposition of the treated soils. The OES units comply with the requirements of 40 CFR 761.70 in the event soils excavated from Area 2 contain PCB concentrations that trigger TSCA regulation. Once permits were obtained, onsite incineration should comply with ARARs if the CFC is operated in compliance with the permits.

Long-term Effectiveness and Permanence

Onsite incineration would permanently destroy the VOCs. Treatment generates fly and bottom ash and air emissions. The treated soils would be analyzed for metals by the TCLP to determine whether the soils could be replaced in the excavated area or required further treatment to meet treatability variance levels or other levels promulgated for soils in compliance with the land disposal restrictions (40 CFR 268).

Reduction of Toxicity, Mobility and Volume Through Treatment

Incineration would permanently reduce the mobility, toxicity, and volume of the VOCs in the soils. Metals concentrations, though not known to be a concern, are concentrated in the treated soils and may require further treatment.

Short-term Effectiveness

Potential short-term risks posed by excavating and incinerating the VOC-contaminated soils were presented above under protection of human health and the environment. During incineration there would be additional potential for worker exposure to gaseous emissions from the unit. Acid gases would be controlled by adding limestone to the feed. The control of other emissions would require pilot-scale testing to ensure that resulting emissions would not pose an unacceptable risk to human health or the environment. Worker exposure would be controlled by an induced current draft fan located at the base of the exhaust stack which draws air through the unit. Bottom ash is cooled prior to discharge, reducing the possibility of worker contact and injury. Short-term risks during excavation and staging activities could be minimized by adhering to a health and safety plan.

The potential short-term effects of stormwater run-off, soil erosion, or leaching on the quality of the stream channels from excavation and incineration could be minimized using engineering controls. Incineration would have no effect on the ground water or the Hackensack Meadowlands estuary system or other sensitive environmental systems. There would be limited additional truck traffic in the area, since the waste is treated onsite.

An estimated 16 months would be required to excavate and incinerate the VOC-contaminated soil, as shown in Table 3-3. The estimate assumes that soils can be incinerated and the site restored immediately. The estimate does not allow for delays due to weather or treated soils analyses. Equipment downtime is assumed to be 40 percent. Permitting an incinerator in this region may be very difficult. An estimated 24 months will be required to secure an air permit for this activity. The estimated overall time required to implement this alternative is 59 months.

Implementability

Bench-scale tests would be required to determine the feasibility of using the CFC unit at the UOP Site given permitting limitations in northern New Jersey. Specifically, bench-scale tests would be performed to determine the Btu, halogen, sulfur, and ash content of the soils.

The CFC treats from 2 to 5 tons of soil per hour, depending upon the soil characteristics, operating 24 hours per day, 365 days per year. There are currently four CFC units available from OES. Units are in high demand and may be difficult to procure in a timely manner. All support equipment, including water and power must be supplied onsite.

Cost

The present worth estimated for onsite incineration is $11.9 million, presented in Table 3-2 and Appendix A. Costs assume the treated soils will be deposited in the excavation areas.

Summary

Onsite incineration would destroy the VOCs and other organics present in the soils. Incineration does not destroy metals. Metals are not known to pose a problem; however, the treated soils would be analyzed for characteristic toxicity to ensure that the soils could be returned to the site.

The CFC system is easily transportable and can be constructed onsite in less than a month. There are four units currently in use; units are available for remediation in the latter part of 1990. A test burn would be necessary to confirm the feasibility and cost-effectiveness of this alternative. Onsite incineration would require an estimated 59 months to complete. The estimated present worth of incinerating VOC-contaminated soils in the CFC is $11.9 million.

Off-site Incineration

Description

Off-site incineration was evaluated based on the rotary kiln incinerator due to the availability of commercial facilities. The rotary kiln incinerator consists of a refractory-lined cylindrical kiln, a secondary combustion chamber, an air-pollution control system, a process stack, and supporting equipment. The process is described in detail in FS Section 4.2.3.

Evaluation

Overall Protection of Human Health and the Environment

Excavation and offsite incineration in a permitted rotary kiln is a proven method of treating CERCLA soils and would permanently destroy the VOCs. The ash and emissions produced should be managed in accordance with the facility operating license in compliance with applicable regulations. The potential endangerment to human health and the environment associated with permitted activities should be minimal. Excavation and transport poses potential short-term human health and environmental risks but these risks could be minimized by adhering to a health and safety plan and EPA, OSHA, DOT, and DEP regulations.

Compliance with ARARs

Action specific ARARs are listed in Table 3-1. This alternative complies with the identified ARARs.

Long-term Effectiveness and Permanence

Offsite incineration effectively eliminates the VOCs of NJDEP concern from the UOP Site. Incineration generates ash and air emissions; however, the ash would be managed in a licensed facility in compliance with facility operating permits. In the long-term, removal would eliminate the potential need for periodic monitoring and land use restrictions.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Removal and offsite incineration permanently reduces the toxicity, mobility, and volume of VOC-contaminated soils. The ash may contain hazardous concentrations of leachable metals. If necessary, the ash would be stabilized at the licensed facility to immobilize the metals prior to landfilling.

Short-term Effectiveness

In the short-term, excavation and staging of the soils prior to facility approval of the soil shipments would pose potential human health and environmental risks. Soils would have to covered during all staging operations to minimize volatilization of the VOCs. The short-term risks of exposure during excavation, loading, and transport could be minimized, but not eliminated, by adhering to an approved health and safety plan. The potential environmental effects of excavation and increased truck traffic, such as site drainage alterations and soil erosion would be minimized by engineering controls. There would be little or no projected adverse impact on the ground water or the Hackensack Meadowlands estuary system or other sensitive environmental systems.

This alternative could be implemented within an estimated 64 months. As shown in Table 3-3, the estimated time assumes limited capacity at the permitted incineration facility that would require 36 months to stage the transport of soils to the facility. The estimate does not include time required to receive approval at a permitted facility or possible delays in site activities due to weather.

Implementability

Commercial incineration facilities are readily available. The limited facility capacity will require extended periods to complete remediation. Onsite activities, such as air monitoring, decontamination facilities, and security, will have to be maintained during the entire remediation process. Bench- or pilot-scale tests may be required to determine whether the soils can be incinerated at the proposed facility.

Cost

The total present worth to excavate and incinerate the soils offsite is $103.9 million, presented in Table 3-2 and Appendix A.

Summary

Excavation and offsite incineration would be an effective method of removing the VOCs of NJDEP concern from the UOP Site and permanently destroying the VOCs. Excavation and staging pose potential short-term risks to site workers and the environment. Transport to the licensed facilities poses increased risks of transportation accidents. Once implemented, incineration provides a permanent reduction in the toxicity, mobility, and volume of the contaminated soils. The ash can be stabilized prior to disposal if necessary. Excavation and offsite incineration can be easily implemented assuming the soils are readily accepted at a licensed facility. Limited capacity at available incinerators will result in an extended period of time for remediation which results in a correspondingly extended risk of exposure to the VOCs. Offsite incineration will require an estimated 64 months and an estimated present worth of $103.9 million to complete.

3.4.3 Soil Washing

Description

Soil washing is applied to separate the target compounds from the soils to obtain a liquid phase that is more amenable to further treatment. A variety of washing solutions have been developed for an array of compounds and combinations of compounds. Several vendors offer proprietary processes. The soil washing process was described in the FS Section 4.2.3; please see the FS for a complete description of the process. For the purpose of this analysis, the B.E.S.T.^{R} process was used to evaluate soil washing. Other processes may be selected during remedial design.

Evaluation

Overall Protection of Human Health and the Environment

Excavation and washing of the VOC-contaminated soil would separate the VOCs from the soil matrix, transferring the VOCs to a liquid phase that is more amenable to treatment. The VOCs of concern would be removed, eliminating the source of potential concern to NJDEP. Residual contaminants and treatment chemicals may remain on the soils. Excavation, materials handling, and treatment activities pose potential risks to human health and the environment due to the increased mobility of the VOCs. Precautions would be required to prevent release of VOCs to the atmosphere or in runoff from soils with precipitation or dewatering. The potential exposure risks could be minimized with engineering controls and through the health and safety plan. The B.E.S.T.[R] treatment unit is a closed loop system designed not to release emissions.

The potential impacts of stormwater run-off, soil erosion, and leaching on the quality of surface water in Ackerman's Creek from excavation and soil washing would be identical to other excavation and treatment alternatives and could be minimized using engineering controls. Soil washing should have no effect on the ground water or the Hackensack Meadowlands estuary system.

Compliance with ARARs

Action specific ARARs are presented in Table 3-1. A Type B permit would be required to excavate the soils and debris. A NJPDES permit would be required to discharge the treated water to the stream channels. Tests would be required to determine if treated soils could be returned to the site.

Long-term Effectiveness and Permanence

The VOCs would be permanently separated from the soil matrix in the soil washing process. The contaminants are transferred to a liquid phase which is intended to be more amenable to treatment. If the liquid(s) generated is incinerated, the VOCs would be permanently destroyed. Low levels of residual contamination and treatment chemicals may remain on the soils.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Soil washing reduces the toxicity, mobility, and volume of contaminated soil by transferring the VOCs from the soil to a liquid form that would require further treatment. If incinerated, the byproducts of soil washing are destroyed, thus providing permanent treatment. Residuals may remain on soils.

Short-term Effectiveness

In the short-term, remediation activities will pose short-term risks to site workers, as described above. These short-term risks are identical to the risks posed by other alternatives with the exception of the materials handling required to achieve a maximum 1/4 inch particle size for soil washing. The increased risks posed by additional materials handling may be minimal and could be controlled by adhering to a health and safety plan.

The total estimated time required to wash the VOC-contaminated soil is approximately 17 months, shown in Table 3-3. This estimate assumes that the soil washing process will not be significantly delayed due to weather or the availability of treatment units. The estimated overall time required to implement this alternative is 47 months.

Implementability

The availability of equipment could cause some delay in implementing this alternative. There is presently a 1 1/2 year backlog for B.E.S.T. units. Soil washing equipment can be chemically and mechanically complex. Unit design, mobilization, startup, and operation may involve delays in implementation.

Soil washing effectiveness depends on the characteristics of the soils and the number of washing stages necessary to remove the target compounds. Bench- and pilot-scale tests would be necessary to determine the materials-handling restrictions and treatment efficiency. Analysis of the liquid phases generated in bench- and pilot-scale tests would provide data on the proper handling and need for additional treatment of the process wastes.

Cost

The estimated present worth for soil washing is $10.1 million, presented in Table 3-2 and Appendix A.

Summary

Soil washing could effectively treat the VOC-contaminated soils; however, precautions must be taken to minimize and control volatilization of the VOCs during excavation, materials handling, and treatment. The greatest concern with the effectiveness of this alternative is the heterogeneity of the waste and the potential difficulty in handling and treating the waste with consistent, successful results. Based upon the capabilities of representative treatment processes, washing with an organic solvent would effectively remove the VOCs from the soil and, depending upon the wash solvent used, convert the metals to a hydroxide form. Pilot tests would be necessary to confirm the feasibility and cost-effectiveness of this alternative. Depending upon equipment availability and materials handling requirements, the alternative could be readily implemented. This alternative would require 47 months to complete, depending on the size and number of treatment units. The estimated present worth of treating the VOC-contaminated soils using soil washing is $10.1 million. The cost assumes that liquids generated in the process would be incinerated offsite. The cost also assumes that the treated soils would be returned to the excavated areas.

3.4.4 Thermal Desorption

Description

Thermal desorption units are designed to separate organic compounds from soils by enhancing volatilization under increased temperatures and pressures. Several vendors have developed commercial thermal desorption units. The X*TRAX[R] unit, offered by Chemical Waste Management was used as the basis for the evaluation of thermal desorption in the FS. The X*TRAX[R] process and the theory of thermal desorption are presented in the FS Section 4.2.3. The X*TRAX[R] unit was also used as the basis for the evaluation of thermal desorption in this Addendum, presented below. However, other processes may be selected during the remedial design.

Evaluation

Overall Protection of Human Health and the Environment

Thermal desorption would separate the VOCs from the soils, transferring the VOCs to a condensate and a filter cake that is intended to be more amenable to treatment. Although expected to be minimal, residual contamination may remain on the soils. Precautions must be taken to minimize and control VOC emissions during soils excavation, materials handling, and staging. Emissions from the off-gas treatment unit may be a source of short-term exposure, although bench-scale tests would determine whether the emissions would pose a significant risk. As with other onsite treatment alternatives, excavation and staging and treatment unit assembly pose short-term human health and environmental risks. The short-term risks can be minimized, but not prevented, by adhering to a health and safety plan and with engineering controls.

Compliance with ARARs

Action specific ARARs are listed in Table 3-1. A Type B permit would be required to excavate the soils and debris. Bench-scale tests would be required to determine whether thermal desorption meets the Federal and state air emission standards.

Long-Term Effectiveness and Permanence

Thermal desorption should remove the VOCs from the soils and would be amenable to permanent treatment. Some residual contamination may remain on the soils, although it is expected to be minimal.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Thermal desorption would strip the VOCs from the contaminated soil, effectively reducing the volume of contaminated media. The VOCs would be contained in the filter cake or condensate, both of which require further treatment. If the byproducts of thermal desorption are incinerated, the VOCs would be permanently destroyed.

Short-Term Effectiveness

Excavation and thermal desorption would pose the same short-term risks to onsite workers as other action alternatives but could be minimized with engineering controls. Emissions from the off-gas treatment unit may create short-term health risks.

The time required to implement thermal desorption is an estimated 13 months, as presented in Table 3-3. This estimate does not allow for delays due to weather or analyses of treated soils and condensate. Equipment downtime is assumed to be 40 percent. The estimated overall time required to implement this alternative is 48 months.

Implementability

The X*TRAX[R] unit requires that soils be screened to a maximum two-inch particle size to be amenable for treatment. A pilot study would be necessary to determine site-specific feasibility. The process is moderately complex, and delays may be encountered as a result of design, construction, startup, and operation.

Site preparation would involve grading the site and providing a firm base such as compacted gravel. Concrete housekeeping pads may be required. The transportable X*TRAX[R] model 200 unit can be mobilized in three to four weeks. It is a full scale production unit which is capable of treating 125 tons of contaminated soil per day with a 20 percent moisture content. The onsite treatment unit is comprised of three semi-trailers, one control room trailer, eight equipment skids and various pieces of removable equipment. The system requires three phase, 460 volt electric power, propane storage tanks, and a liquid nitrogen storage tank. The electric motors are sized such that the system can be operated from a commercially available diesel generator.

Cost

The present worth of treating the soils using thermal desorption is an estimated $11.6 million, presented in Table 3-2 and Appendix A. This estimate assumes that the filter cake and condensate are incinerated offsite and that the treated soils are returned to the excavated areas.

Summary

Based on an evaluation of the X*TRAX[R] unit, thermal desorption could be a viable treatment technology for the VOC-contaminated soils. Thermal desorption does not destroy the organic contaminants, but separates them from the solid matrix. Metals and low levels of residual organics remain in the soils. TCLP analyses of the treated soils would determine whether the soils could be replaced in the excavation area or require further treatment to meet the treatability variance levels or promulgated standards for soils to comply with the land disposal restrictions. This analysis assumes the condensed organics in the oil and filter cake would be incinerated offsite; however, other treatment methods may be selected during remedial design. The X*TRAX[R] unit is readily available for treatment. Pilot tests would be necessary to determine the feasibility and cost effectiveness of this alternative. Thermal desorption would require 48 months from initiation to completion. The estimated present worth is $11.6 million.

3.4.5 Vacuum Extraction

Description

Vacuum extraction refers to the process of stripping VOCs from the soils. The effectiveness of vacuum extraction depends on the volatility of compounds in the soil, the rate of air circulation through the soil, and the soil moisture and permeability.

Vacuum extraction would be carried out by excavating the soil and allowing the soil to passively drain. The soil would be placed on an impermeable liner that may have a leachate collection system in place to collect leachate draining from the soil. Perforated or slotted pipes would be placed within the pile, and individual extraction vents would be connected through a manifold to an exhaust blower. The exhaust blower pulls air through the soil. Air may be injected into the soil in order to increase the air flow through the soil and improve system performance. Depending upon the level of moisture required in the soil, the air could be humidified prior to injection.

The system can be designed to capture VOCs released from the surface by covering the soil treatment bed with weighted sheeting for short-term treatment, or a modified plastic-film greenhouse arrangement.

The process would treat VOC emissions by directing the emissions from the exhaust blower to a control such as an vapor-phase activated carbon adsorption unit or a catalytic burner, preceded by a water trap to prevent water from entering the downstream units. The choice of an emissions control option would depend in part on the expected duration of treatment, VOC concentration, and the resulting costs. Long-term treatment of heavily-contaminated soil has generated large volumes of activated carbon. Emissions control methods would be determined during final design, and based on the results of the pilot testing activities.

Bench and pilot scale studies would be required prior to full-scale implementation to determine the effectiveness of vacuum extraction under site conditions. The purpose of the tests would be to examine the air permeability of the soil, the effect of different air flow rates, potential mass transfer rates from soil to air, and the potential air emissions. This information would allow determination of design and operating criteria of the treatment system, such as the air flow rates, the spacing of pipes, and the type of air emissions control required.

Following vacuum extraction, it is assumed for the purpose of this FS that the treated soils will be suitable for use as backfill onsite.

Evaluation

Protection of Human Health and the Environment

Vacuum extraction, in conjunction with vapor emissions control, such as carbon adsorption or catalytic incineration, could effectively protect human health and the environment by removing VOCs from the soil. Excavation and materials handling pose potential short-term risks from exposure to VOCs. These risks can be controlled, but not eliminated, by following a health and safety plan.

Compliance with ARARS

The action-specific ARARS are presented in Table 3-1. Vacuum extraction would comply with the ARARs, though the appropriate permits would be required to discharge or otherwise dispose of water that drains from the excavated soil, and to return the treated soils to the excavated area. Air emissions during treatment must be controlled to comply with state and Federal regulations.

Long-term Effectiveness and Permanence

Vacuum extraction will permanently transfer VOCs compounds from the soil to the air where the VOCs can be adsorbed to vapor-phase activated carbon or destroyed by a catalytic incinerator. The spent activated carbon will either be regenerated or otherwise treated or disposed of. Vacuum extraction will not remove nonvolatile, or even all semi-volatile, materials. Bench- and pilot-scale testing would be required to determine the efficacy of the alternative in removal of contaminants for the specific soil being considered.

Reduction of Toxicity, Mobility and Volume Through Treatment

The mobility and volume of the contaminants would be reduced by vacuum extraction. The VOCs would be adsorbed to activated carbon, assuming the use of carbon as a vapor emissions control system, or destroyed in a catalytic incinerator. In the former case, the spent activated carbon would require regeneration.

The process by which vacuum extraction is carried out would enhance natural biodegradation processes in the soil. Thus the VOC concentration may be reduced in part by biodegradation.

Short-term Effectiveness

Short-term risks associated with the excavation and handling of the contaminated soil exist, as site activities pose increased exposure risks to workers. Risks would be minimized by adherence to a health and safety plan. During treatment, risks are minimized by the presence of air emission controls such as activated carbon adsorption on the vacuum extraction system.

Onsite vacuum extraction would require an estimated 27 months to implement, as shown in Table 3-3. This estimate assumes that the findings of bench-scale studies confirm the effectiveness of vapor extraction of VOCs from the soil, and that site activities would proceed with minimal interruptions from weather, contractor and other administrative delays.

Implementability

Vacuum extraction of excavated soils is a relatively new technology. The vacuum extraction equipment and air emissions control equipment are readily available or easily constructed. Tests would be required to examine the feasibility and cost-effectiveness of vacuum extraction, and to determine design and treatment parameters.

Implementability would be limited by the characteristics of the soil, with soil type, air permeability, contaminant type and concentration, and moisture content being of concern.

Cost

Remediation of the soils in Areas 1 and 2A using vacuum extraction following excavation to remove VOCs is estimated to cost $4.9 million, as shown in Table 3-2 and Appendix A.

Summary

If testing establishes the feasibility of vacuum extraction as a remediation measure, vacuum extraction would remove VOCs from the soil. Short-term risks in implementing the excavation and materials handling phases could be minimized by adhering to the health and safety plan. Engineering controls such as carbon adsorption for vapor phase control on the exhaust air drawn from the vacuum extraction system would be implemented during treatment. Bench- and pilot-scale tests will be required to determine the efficacy of the process for treatment of the soils in Areas 1 and 2A. If selected, this remedial alternative would take about 59 months and $4.9 million to implement.

3.5 Excavation and Disposal - Offsite Landfill

Description

This alternative involves excavating the VOC-contaminated soils in Areas 1A and 5 and disposing of the excavated materials in a RCRA-permitted landfill. Standard construction equipment would be used to excavate the soils and excavation areas would have to be dewatered, as described in Section 2.2.2. An estimated 21,600 cubic yards of soil would be excavated, of which 3,200 cubic yards could be managed as clean soil. Assuming a 20 percent expansion factor upon excavation and deducting the volume that can be managed as clean soil, a total of 22,080 cubic yards of contaminated soil would require disposal.

Disposal of the excavated soils and debris will have to be conducted in accordance with RCRA regulations in accordance with SARA. Section 121(d)(3) of SARA requires that hazardous substances, pollutants, or contaminants be disposed of at a facility in compliance with Sections 3004 and 3005 of RCRA and applicable state requirements. First, the excavated soils may need to be dewatered to pass the Paint Filter Liquids Test (PFLT) for free liquids. The water collected and the dewatered soils would have to be analyzed to determine their respective destinations.

Liquids generated during excavation and dewatering may have to be treated either on- or off-site as analyses dictate. If the water collected from Area 2 excavation activities or dewatering Area 2 soils contain greater than or equal to 500 ppm PCBs, the water must be incinerated or treated by another EPA-approved method that achieves the required destruction and removal efficiency, according to TSCA 40 CFR 761.70 standards. Liquid wastes containing PCBs at concentrations greater than or equal to 50 ppm and less than 500 ppm are regulated under the land disposal restrictions (40 CFR 268).

Excavated soils would have to be analyzed to ensure that they do not exhibit characteristics subject to the land disposal restrictions. Treated soils would be analyzed for organics and metals by the TCLP to determine whether the soils could be redeposited in the excavated areas or if further treatment would be needed to meet treatability variance levels under the land disposal restrictions. If soils contain greater than 50 ppm PCBs, they are subject to TSCA regulation and must be disposed of or treated in facilities that comply with 40 CFR 761.75 and 40 CFR 761.70, respectively.

Transportation of CERCLA soils is regulated by the U.S.

Department of Transportation and U.S. EPA, and state, and local ordinances. Hazardous waste transport vehicles must display the proper DOT placard. Contaminated soil is generally hauled in box trailer, flat-bed truck, or roll-off container. Trucks and railcars must also be lined with plastic and or absorbent material. The transport vehicle would be directly filled from excavation equipment or staging areas and sealed.

The estimated soil volumes to be excavated and disposed of offsite could present logistical transportation problems and a high potential for exposure to the VOCs. Assuming that 20 cubic yard trucks were used to transport the soils, over 1,000 truckloads of soils would be transported offsite.

Upon completion of excavation activities, the site would be restored using readily available backfill, regraded, and vegetated. Note that the truck traffic estimates do not include the traffic required to transport the necessary site restoration materials to the UOP Site.

Evaluation

Overall Protection of Human Health and the Environment

Excavation and offsite disposal is a proven method of removing the contaminant source and eliminating the need for long-term monitoring at the site. As with other alternatives involving excavation, excavation activities pose short-term human health and environmental risks due to the increased mobility of the VOCs. The short-term risks would be minimized by strict adherence to a health and safety plan. There is also increased risk of transportation accidents.

Compliance with ARARs

The ARARs identified for this alternative were presented above and are listed in Table 3-1. Excavation and offsite disposal could easily be conducted to comply with ARARs.

Long-term Effectiveness and Permanence

Excavation and offsite disposal of the soils would remove the VOCs of concern from the Site but would transfer the VOCs to another facility. The long-term liability associated with the soils would also be transferred. The long-term liability for removed materials is unknown and potentially great.

Reduction of Toxicity, Mobility, and Volume Through Treatment

The toxicity, mobility and volume of contaminated soil would not change.

Short-term Effectiveness

Removal would transfer the VOCs from the UOP Site to another site. Excavation and staging pose short-term human health and environmental risks. Onsite risks could be minimized by adhering to an approved health and safety plan and engineering controls. Over 1,000 truckloads would be required to transport the soil offsite. The increased truck traffic represents a significant increase in volume and potential risk of transportation accidents on local and state roads and interstate highways.

An estimated 5 months would be required to excavate and dispose of the soils offsite, as shown in Table 3-3. The estimated time assumes that the excavated soils can be transported offsite and disposed of immediately and does not allow for delays due to weather, sampling and analysis, and facility approval. The estimated overall time required to implement this alternative is 27 months.

Implementability

Soils could be easily excavated and transported to a licensed disposal facility. Facilities are readily available.

Cost

The present worth estimated for the implementation of offsite disposal in a permitted landfill is $13.9 million, presented in Table 3-2 and Appendix A.

Summary

The soils and debris that exceed the remediation goal could be easily excavated and transported to a permitted facility or secure landfill as described above. Removal would eliminate the potential risk associated with the soils and debris at the UOP Site. SARA discourages offsite disposal. However, offsite disposal would remove the VOCs of NJDEP concern from the UOP Site. Neither the toxicity, the mobility, the volume, nor the liability associated with the VOCs would diminish. Short-term onsite risks could be easily controlled. Transportation risks would differ with the truck traffic volume, and distances and routes traveled. This alternative would be relatively easy to implement, requiring about 27 months to complete at an estimated cost of $13.9 million.

3.6 In-Situ Treatment - Vacuum Extraction

Description

Vacuum Extraction can operate in-situ in the same manner described above for excavated soils. A piping network would be installed in the soils and connected to a manifold system whereby the VOCs can be withdrawn from the soils by vacuum, effecting mass transfer of the VOCs to the vapor phase.

The medium to low soil permeability and shallow ground water limit the effectiveness of vacuum extraction. To improve effectiveness, the treatment areas would have to be dewatered and the permeabilities increased by methods such as pneumatic fracturing (described below) prior to in-situ treatment.

The treatment areas could be dewatered using either wellpoints or trenches. This analysis assumes that the areas would be dewatered using wellpoints rather than with trenches because of the underground utilities and subsurface drains in the affected areas. Trenches or other means may be selected to dewater the treatment areas during remedial design.

Wellpoints were described above for use in conjunction with the single-layer cap and slurry walls. The wellpoints installed to dewater Areas 1A and 2 would be identical to those previously described, however, spaced and operated to actively dewater the soils.

Pneumatic fracturing is an emerging technology for locally increasing soil permeability. Borings are drilled at 5- to 10-foot intervals depending upon the soil type and formation. A tubular probe is lowered into the boring to deliver compressed air to the desired portion or portions of the substrata. The compressed air creates fissures and channels which enhance permeability. The process can be repeated as necessary to open or maintain fissures.

The pneumatic fracturing process is presently being field tested at a clean site with clayey silt and is proposed for use in demonstrating vacuum extraction enhancement at an industrial site with sand and gravel. Pneumatic fracturing has not been tested in saturated soils. The maximum radius of influence measured in unsaturated silt was 5 feet, with a 4-inch rise in surface elevation. If the soils were effectively dewatered, a similar radius of influence may be achieved at the UOP Site.

Evaluation

Overall Protection of Human Health and the Environment

In-situ vacuum extraction could protect human health and the environment. Site preparation activities, including dewatering and pneumatic fracturing, pose short-term human health and ecological risks from exposure to and migration of the VOCs, respectively. Short-term risks could be minimized, but not eliminated, through use of a health and safety plan and with engineering controls.

Compliance with ARARs

The ARARs identified for in-situ vacuum extraction are presented in Table 3-1. Permits would be required to work within the wetland areas and floodplain. A NJPDES permit would be required to discharge treated water to the stream channels. If the water collected from Area 2 contains 50 ppm PCB concentrations or greater, the water would be regulated under TSCA and the RCRA land disposal restrictions. In addition, treatment must be performed to comply with the NJAC 7:27-16 and 17 emission limitations.

Long-term Effectiveness and Permanence

The long-term effectiveness of in-situ vacuum extraction will be dependent upon the feasibility of dewatering the low to medium permeability soils to 10 and 13 feet depths, increasing the soil permeability by pneumatic fracturing, and creating the required flow of air through the soils. If the alternative can be properly implemented, it would permanently remove the VOCs from the UOP Site soils. However, residual VOCs would likely remain after treatment.

Reduction of Toxicity, Mobility, and Volume through Treatment

If effective, in-situ vacuum extraction should reduce the toxicity, mobility, and volume of VOCs in the soils. The VOCs collected in the vapor phase require further treatment.

Short-term Effectiveness

Implementation activities, particularly dewatering activities, would pose exposure risks to workers and the environment. The collected water and volatilized compounds from the water would have to be controlled to minimize exposure risks. Other risks associated with remediation activities would be similar to those posed by other remediation alternatives although risks associated with in-situ treatment should be lower than other treatment methods.

An estimated 28 months would be required to implement in-situ vacuum extraction in Areas 1A and 2 at the UOP Site. A total of 69 months would be required to complete the remediation process. The total estimated time includes 12 months for pre-design studies by New Jersey Institute of Technology.

Implementability

In-situ vacuum extraction is generally applied to extract VOCs from high permeability unsaturated soils. The technology is not effective in saturated soils where the water hinders movement of air through the soil. Vapor phase recovery is further limited by the mass transfer rate across the air:water interface. The success of the process is also effected by soil permeability in that air is circulated through the soils to enhance volatilization and vapor phase recovery. Given the process constraints, the dewatering and permeability enhancement of the remediation areas is critical to implementation.

Dewatering the sandy silt and clays in Areas 1A and 2 will require many closely-spaced well points. The number and location of well points will be determined following pilot studies of the effects of pneumatic fracturing. Pneumatic fracturing is an emerging technology that has never been tested in saturated soils. Pneumatic fracturing of an unsaturated sand, silt, and clay formation affected an increase permeability within a five feet radius of the boring. If the same effectiveness can be expected in the UOP Site soils, pneumatic fracturing would have to be repeated at 10-foot intervals over the approximately 1 acre of treatment areas. At the 10-foot diameter of influence, well points could likely be spaced at 25 foot intervals. Thus, over 400 borings for pneumatic fracturing and an estimated 70 wellpoints for dewatering would be required to implement vacuum extraction in-situ. Once implemented, the long-term operation and maintenance requirements are uncertain.

Costs

The present worth of using in-situ vacuum extraction with dewatering and permeability enhancement to treat the VOCs in Areas 1A and 2 is estimated to cost $3 million, as shown in Table 3-2 and Appendix A.

Summary

In-situ vacuum extraction could remove the VOCs from the soils. The effectiveness of this alternative is dependent on whether the targeted areas could be efficiently dewatered and the permeability increased by pneumatic fracturing. Site activities may pose short-term exposure risks; however, risks would be minimized by adhering to a health and safety plan and by using engineering controls. Air emission controls would be required to prevent the release of VOCs during site preparation and soil treatment. The VOCs removed from the soils would rehe VOCs from the soils. The effectiveness of this alternative is dependent on whether the targeted areas could be efficiently dewatered and the permeability increased by pneumatic fracturing. Site activities may pose short-term exposure risks; however, risks would be minimized by adhering to a health and safety plan and by using engineering controls. Air emission controls would be required to prevent the release of VOCs during site preparation and soil treatment. The VOCs removed from the soils would require further treatment. This alternative is estimated to require 69 months to implement, allowing a minimum of 12 months for research on and field testing of pneumatic fracturing. Total estimated cost of this alternative is $3 million.

3.7 Summary of Detailed Evaluation

The alternatives evaluated in detail were further evaluated to identify those that satisfy the threshold criteria and meet the remediation goal. All alternatives, including the no action alternative, presently satisfy the threshold criteria. Action alternatives, in the short-term, provide no additional protection over the no action alternative, but rather, pose potential risks. The no action alternative presently poses no risk, as concluded in the risk assessment (ENSR, June, 1989; November 1989) and the FS (ENSR, April 1990).

The remediation goal of 100 mg/kg VOC in soil would be met by all the alternatives, with the exception of the no action and capping alternatives.

In order to balance the respective advantages and disadvantages, the alternatives were comparatively analyzed and qualitatively ranked according to the evaluation criteria. The comparative analysis determines the relative level of protection and cost of each alternative. The results of the comparative analysis of the detailed evaluation are discussed in Section 4.

4

4. RECOMMENDATION OF THE PREFERRED ALTERNATIVE

4.1 Introduction

In this section, the alternatives are comparatively evaluated for each of the seven criteria considered in Section 3. This analysis identifies the relative advantages and disadvantages of each alternative. Table 4-1 summarizes the key items discussed in Section 3 and provides a reference for making comparative evaluations of the alternatives. Table 4-2 provides a qualitative summary of these comparative evaluations. An overall evaluation is then provided in order to recommend the preferred alternative(s).

4.2 Comparative Analysis of Alternatives

Table 4-2 provides a qualitative comparison of remediation alternatives with regard to each of the seven criteria evaluated in Section 3. The rating scale ranges from "++" to "o" to "--", or "well above average" to "average" to "well below average." The choice of rating was based on both objective factors and engineering judgement, as discussed below by criterion.

4.2.1 Protection of Human Health and the Environment

VOC in the soils in Areas 1A and 2 do not pose a significant risk to human health and the environment. Therefore, none of the alternatives was given a negative rating. Positive ratings were given if the alternative provided additional benefit by removing and/or destroying VOCs. Although increased exposure potential may result from the action alternatives, it was assumed that engineering controls and health and safety plans would adequately address this concern. No Action, containment, and offsite disposal were given average ratings. All the treatment

Table 4-1
UOP Site
Area 1A & 2 VOC in Soils
Comparison of Alternatives

Criterion	No Action	Single-Layer Cap and Containment	Bioremediation	Onsite Incineration	Offsite Incineration
Protection of Human Health and the Environment	Currently no risk, no action does not pose any further risk.	Slight increase in exposure from onsite activities.	Will degrade or remove VOC from soil, increase in exposure during remediation activities.	Will destroy VOCs, potential toxic emissions require control, increase in exposure during excavation and handling.	Will destroy VOCs, offsite facility will manage emissions, increase in exposure during excavation and handling.
Compliance with ARARs	Complies with ARARs.	Permits required for wetlands, stream encroachment, water discharge.	Water permit required, air emission controls required.	Air permit required, may be difficult to obtain.	Complies with ARARs.
Long-Term Effectiveness	Would not alter site conditions, VOC will degrade and disperse with time.	Will permanently contain contamination, if properly maintained.	Will permanently reduce VOC concentration in soils.	Will permanently destroy VOCs, treated soils will require testing and possible additional treatment.	Will permanently destroy VOCs, ash and emissions will be properly handled at licensed facility.
Reduction of Toxicity, Mobility, and Volume	None	None	Biotreatment reduces toxicity and volume, VOCs volatilized will be captured by carbon and eventually destroyed.	Reduces toxicity, mobility, and volume of VOC-contaminated soils. Metals remaining may require further treatment.	Reduces toxicity, mobility, and volume of VOC-contaminated soils. Metals remaining in ash may require further treatment prior to disposal in licensed facility.
Short-Term Effectiveness	No change, no increase in risk.	Minor increase in short-term exposure.	Increased short-term risks from soils handling and treatment, exposure controlled with health and safety plan	Increased short-term risks from soils handling and treatment, exposure controlled with health and safety plan	Increased short-term risks from soils handling and transportation, exposure controlled with health and safety plan
		Schedule: 31 months	Schedule: 41 months	Schedule: 59 months	Schedule: 64 months
Implementability	No immediate actions required, will require periodic monitoring.	Possible difficulties with underground utilities and drains. Groundwater may interfere with slurry wall.	Readily available equipment, soil characteristics may cause difficulties.	Bench-scale tests required to demonstrate effectiveness and emission control requirements. Unit must be reserved in advance.	Commercial facilities readily available, but limited capacity will require extended period for completion of incineration.
Cost	$40,000	$1.6 million	$5.4 million	$11.9 million	$104 million

Table 4-1 (cont'd)
UOP Site
Area 1A & 2 VOC in Soils
Comparison of Alternatives

Criterion	Soil Washing	Thermal Desorption	Ex-Situ Vacuum Extraction	Offsite Disposal	In-Situ Vacuum Extraction
Protection of Human Health and the Environment	Will remove VOCs from soils, extract will be destroyed offsite, potential increase in exposure from excavation and treatment activities.	Will remove VOCs from soils, extract and contamination on filter cake will be destroyed offsite, potential increase in exposure from excavation and treatment activities.	Will remove VOCs from soils, VOCs will be destroyed onsite or captured and destroyed offsite, potential increase in exposure from excavation and treatment activities.	Will remove VOCs from site, but transfers to another location. Potential increase in exposure during excavation and transportation activities.	Will remove VOCs from soils, VOCs will be destroyed onsite or captured and destroyed offsite, small potential increase in exposure from drilling and treatment activities.
Compliance with ARARs	Tests required to determine if treated soils can be returned to site or if further treatment is necessary.	Tests required to determine if treated soils can be returned to site or if further treatment is necessary.	Will comply with ARARs with appropriate permits.	Will comply with ARARs.	Will comply with ARARs with appropriate permits and emissions controls.
Long-Term Effectiveness	Will permanently remove VOC from soils, removed VOC will be permanently destroyed. Low levels of treatment chemicals may remain in soils.	Will permanently remove VOC from soils, removed VOC will be permanently destroyed.	Will permanently remove VOCs from soil, performance to be determined. Non-volatile and semi-volitile materials will not be appreciably removed.	Permanently removes VOCs from site, but transfers contamination.	Will permanently remove VOCs from site, efficiency to be determined, residual VOC likely to remain.
Reduction of Toxicity, Mobility, and Volume	Reduces toxicity, mobility, and volume, separated VOC treated offsite, soils may require further treatment prior to redepositing onsite.	Reduces toxicity, mobility, and volume, separated VOC treated offsite, soils may require further treatment prior to redepositing onsite.	Reduces toxicity, mobility, and volume, may require extended treatment to achieve low levels. Process will promote natural biodegradation.	None	Reduces toxicity, mobility, and volume, may require extended treatment to achieve low levels. Process will promote natural biodegradation.
Short-Term Effectiveness	Potential short-term increase in exposure during excavation and treatment activities. Schedule: 47 months	Potential short-term increase in exposure during excavation and treatment activities. Schedule: 48 months	Potential short-term increase in exposure during excavation and treatment activities. Schedule: 59 months	Potential short-term increase in exposure during excavation and transfer activities. Schedule: 27 months	Potential short-term increase in exposure during drilling and treatment activities. Schedule: 69 months
Implementability	Limited number of units available, must schedule far in advance, complexity of process may cause delays. Bench and pilot tests needed.	Variety of vendors available, complexity may delay implementation	Relatively new technology, but constructed with readily available equipment. Pilot tests necessary for design parameters.	Facilities readily available.	Extensive dewatering required, pneumatic fracturing is an emerging technology whose effectiveness is uncertain.
Cost	$10.1 million	$11.6 million	$4.9 million	$13.8 million	$3 million

Table 4-2
UOP Site
Areas 1A and 2 – VOCs in Soils
Summary of Remedial Alternatives

Technology Alternative

Criterion	No Action	Cap and Containment	Bioremediation	Onsite Incineration	Offsite Incineration	Soil Washing	Thermal Desorption	Ex-Situ Vacuum Extr.	Offsite Disposal	In-Situ Vacuum Extr.
Protection of Human Health and the Environment	O	O	+	+	+	+	+	+	O	+
Compliance with ARARs	O	–	O	–	O	O	O	O	O	O
Long-Term Effectiveness	--	–	+	++	++	+	++	O	O	O
Reduction of Toxicity, Mobility, and Volume	--	–	+	++	++	+	++	O	–	O
Short-Term Effectiveness	++	+	–	–	--	–	–	--	O	--
Implementability	++	O	O	--	--	–	O	–	+	--
Cost	++	+	O	–	--	–	–	O	–	++
Overall Evaluation	--	--	+	O	–	O	O	+	O	+

Legend

- ++ = well above average
- \+ = above average
- o = average
- \- = below average
- -- = well below average

technologies were given above average ratings.

4.2.2 Compliance with ARARs

All of the alternatives will comply with ARARs. Applicable ARARs differ for the various alternatives, but compliance is expected to be a matter of engineering design, controls, and permitting. Therefore, most alternatives were given an average rating. The only exceptions are onsite incineration, which may meet insurmountable permitting hurdles, and containment, which may result in permitting difficulties with regard to erosion and drainage. These two were given below average ratings.

4.2.3 Long-Term Effectiveness

Onsite incineration, offsite incineration, and thermal desorption were rated highest because they are expected to provide the most complete destruction of VOCs. Bioremediation and soil washing were rated slightly lower because, although they can remove VOCs, it is possible that residual contamination will remain in the soils. With soil washing, residual treatment chemicals may also remain. In-situ and ex-situ vapor extraction can remove most of the VOCs, but some residual amount will likely remain, and it will be difficult to monitor the effectiveness of the process on all areas of contamination; therefore, an average rating was given. Containment reduces risk by providing a barrier to exposure, but the VOCs in soil will still exist; therefore, a below average score was given. Offsite disposal will transfer the VOC to another site. Although the soils would be in a controlled facility, there would be no VOC removal; a below average rating was given. No Action provides no reduction of VOC and was given the lowest rating.

4.2.4 Reduction of Toxicity, Mobility, and Volume with Treatment

Incineration, both onsite and offsite, and thermal desorption can essentially eliminate VOCs in the soil; these were given the highest rating. Bioremediation and soil washing will remove most of the VOCs, but may leave contaminant residuals. Vacuum extraction will likely leave higher levels of residuals, potentially in pockets of high concentration. Containment and offsite disposal do nothing for this criterion by definition, but provide some control over accidental exposure. No Action provides no reduction or control; thus the lowest rating.

4.2.5 Short-Term Effectiveness

These ratings are based primarily on potential exposure during the remediation activity and on remediation schedule. No Action received the highest rating because there would be minimal activity onsite to allow exposure, and implementation time would be minimal. Containment would result in limited contaminated soil movement during slurry wall construction, and therefore low potential for exposure in the short term. Also, remediation time is short, compared to other alternatives. Containment was given a better than average rating. Offsite disposal was considered average because of the short time required to implement, offset by the increased exposure potential and increased risk of truck accidents. Bioremediation, onsite incineration, soil washing, and thermal desorption will require more time to implement, due to permitting and equipment limitations. These alternatives were therefore given below average ratings. The onsite incineration schedule could be severely impacted by permit concerns, which would lower this rating. Offsite incineration received the lowest rating because of the capacity limitations of existing licensed incinerators and the length of time that would be required to complete the remediation. Both in-situ and ex-situ vacuum extraction were also rated well below average because of the long time required for the actual remediation time required.

4.2.6 Implementability

No Action received the highest rating because there are minimal barriers to its implementation. Offsite disposal was rated above average because of the short time required to implement. Containment, bioremediation, and thermal desorption were considered only average because potential design or permitting problems may cause delays. Soil washing was rated below average because of its higher mechanical and chemical complexity and the potential for longer design, mobilization, and startup times. Ex-situ vacuum extraction will require a long period of operation, the reason for a below average rating. Onsite incineration was rated well below average primarily because of the permitting time and the potential for even longer delays than estimated. Offsite incineration received low rating because of the limited capacity of existing incinerators and the long time required to treat the soils. In-situ vacuum extraction will also take several years to implement. The alternatives that require several years to perform the actual remediation will also require site activities such as maintenance, monitoring, security, decontamination facilities, and reporting for the duration of the project.

4.2.7 Cost

The cost of each of the alternatives is provided in Table 4-1. No Action was the least costly and was therefore rated highest. In-situ vacuum extraction also had a significant cost advantage over the remaining alternatives, and was therefore rated well above average. Containment was in the next highest category of costs, an above average rating. The next cost grouping, considered average, included bioremediation and ex-situ vacuum extraction. The next grouping, considered below average, included soil washing, thermal desorption, onsite incineration, and offsite disposal. Offsite incineration was by far the most expensive option. These cost numbers could vary significantly, depending on site specific factors, weather delays, mobilization costs, insurance and liability, and volume of soils to be remediated.

4.3 Selection of Preferred Alternative(s)

The NCP outlines procedures for recommending the preferred alternative. The first step in recommending a preferred alternative is to eliminate those alternatives that do not meet the threshold criteria of protection of human health and the environment and compliance with ARARs. Since all of the alternatives meet these threshold criteria, none were eliminated on this basis. If a risk-based approach is taken, then no action is preferred, because the VOC-contaminated soils pose no significant risk and there would be no activities that would increase exposure. If removal and/or treatment of soils contaminated with VOC concentrations above 100 mg/kg is required to address NJDEP concerns, no action and containment can be rejected. Of the remaining alternatives, the preferred approach to remediation of the UOP site is in-situ vacuum extraction because of low cost and minimal increase in potential exposure during remediation activities. In-situ vacuum extraction alone in dewatered low permeability soils is expected to be difficult; however, pneumatic fracturing is an innovative technology that can be used in conjunction with vacuum extraction to potentially enhance the extraction rate and efficiency. An extended field study may be required with this alternative to confirm practicality and performance.

In the event that in-situ vapor extraction is not viable, ex-situ vacuum extraction or bioremediation are preferred. The other treatment technologies will be equally as effective, but costs are much higher. In any event, the chosen alternative will require pilot or field testing to confirm effectiveness and to assess treatment economics.

5

5. SUMMARY OF OVERALL APPROACH TO UOP SITE REMEDIATION

5.1 Introduction

This section provides a summary of the recommendations for UOP Site remediation presented in both the Feasibility Study and the FS Addendum. The purpose of this section is to discuss the interaction of the remediation recommendations presented in each document and to develop an overall approach to remediation of the site.

5.2 Summary of Recommended Remediation Alternatives

5.2.1 Feasibility Study: Soils and Debris in Area 5

The Feasibility Study for Areas 1, 1A, 2, and 5 addresses site contamination that exceeds the risk-based remediation goals. PCB and PAH-contaminated soils in Area 5 are the only soils requiring remediation on this basis. The volume of soil to be remediated is estimated to be 6800 cubic yards. The recommended treatment alternative is soil washing or thermal desorption. Each alternative will require soil excavation and screening prior to feeding to the treatment process. Soils will be treated as necessary to be made suitable for redeposition on the site. Each process is capable of treating the soil to below the remediation goal of 29 mg/kg for PAHs and below the 50 mg/kg TSCA limit for PCBs. Removed contamination will be destroyed by incineration or other effective technology. Implementation time for the actual remediation activity is estimated to be 8 to 11 months; total time for implementation is 40 to 41 months. Exposure will be minimized with engineering controls and a health and safety plan. Estimated costs are $4 to $6 million.

The second choice for remediation of Area 5 soils is offsite disposal because this approach will quickly remove the contamination from the site and place it in a controlled facility. Excavation is required, and the site will be backfilled with clean soil. Total implementation time is 27 months, and estimated cost is $6 million. The next level of choices includes solidification and onsite incineration.

5.2.2 Addendum: VOC in Soils in Areas 1A and 2

The Addendum addresses VOCs in soils at concentrations above the remediation goal of 100 mg/kg. An area measuring approximately 200 ft by 200 ft in Area 1A and an area measuring approximately 30 ft by 50 ft in area 2 were identified as the soils that exceed the remediation goal. The total volume of soil to be treated is approximately 18,000 cu yd. The recommended treatment alternative is in-situ vacuum extraction, used in conjunction with dewatering and pneumatic fracturing. No excavation is required, but many wells will be drilled in the soils to implement the pneumatic fracturing technique and to install the dewatering and vacuum extraction systems. Because the soils are not excavated, redeposition of treated soils onsite is not required. Although extensive pilot tests will be required to demonstrate effectiveness, in-situ vacuum extraction is considered to be capable of readily achieving the 100 mg/kg remediation goal. Removed contamination will be destroyed by incineration or other effective methods. Implementation time for the technology is expected to be 28 months, and total time to complete the remediation is 69 months. Exposure will be minimized with engineering controls and a health and safety plan. Estimated costs are $3 million.

The next choice of remediation alternative is either ex-situ vacuum extraction or bioremediation. Each requires excavation and redeposition of soils. Total implementation time is 40 to 60 months. Estimated cost of either alternative is $5 million. The next level of choices for VOC remediation includes offsite disposal, soil washing, and thermal desorption, with costs ranging from $10 to $14 million.

5.3 Considerations for a Combined Remediation Effort

This analysis was conducted to determine if the combining of remediation efforts for Area 5 soils with Area 1A and 2 soils could result in savings of time and money. A combined effort could avoid duplication of effort and costs for activities such as design, pilot tests, work plan preparation, permitting, mobilization, and coordination. The following facts and observations were considered in this analysis:

Area 5 soils will require excavation. The soils treated by soil washing or thermal desorption may require additional treatment prior to being returned to the site. Soils treated in-situ will not require additional treatment.

The volume of VOC-contaminated soils is approximately three times the volume of PAH and PCB-contaminated soil.

Estimated remediation time for Area 5 soils with soil washing or thermal desorption is approximately 3.5 years. Remediation time for in-situ vacuum extraction is approximately 6 years.

Area 5 soils currently pose risks that exceed 1×10^{-6}. VOC contaminated soils pose no significant risks to human health and the environment.

The VOC-contaminated soils in Areas 1A and 2 could, in theory, be treated by vacuum extraction, bioremediation, soil washing, or thermal desorption. The PCB- and PAH-contaminated soils in Area 5 could be treated only with two of the four technologies: soil washing and thermal desorption. A combined treatment approach, therefore, could consider only these two technologies. The cost of VOC-contaminated soil treatment with soil washing or thermal desorption is a factor of 3 to 4 higher than the preferred alternative of in-situ vacuum extraction and a factor of 2 higher than the cost of ex-situ vacuum extraction or bioremediation, the second choices for VOC-contaminated soils. The potential cost savings in design, permitting, and mobilization that could be realized by using a single technology are far below the additional treatment costs that would be incurred.

Based on the above items, it was concluded that there would be little advantage to choosing a single remediation technology to treat the UOP Site soils. Therefore, the recommendations for treatment alternatives remain separate as presented in the Feasibility Study and the Addendum.

REFERENCES

Baumister, T., Marks' Standard Handbook for Mechanical Engineers New York, Mcgraw-Hill, Inc., 1978, pp. 6-8.

Bourquin, Al W. "Bioremediation of Hazardous Waste." HMC. September/October 1989. pp. 16-59.

ENSR Consulting and Engineering. "Feasibility Study for Areas 1, 1A, 2 & 5, UOP Site, East Rutherford, NJ" April 1990.

ENSR Consulting and Engineering. "Risk Assessment Report UOP Site, East Rutherford, New Jersey" Volume I Human Health Risks, June 1989.

ENSR Consulting and Engineering. "Risk Assessment Report UOP Site, East Rutherford, New Jersey" Volume II Ecological Risks, November 1989.

Environmental Law Institute. Compendium of Cost of Remedial Technologies at Hazardous Waste Sites. Prepared for U.S. EPA Office of Emergency and Remedial Response. p. 1-7. 1984

Geraghty & Miller, Inc. "Remedial Investigation Report, Areas 1, 1A, 2, and 5, UOP SITE, EAST RUTHERFORD, NEW JERSEY" Revision No. 1, Vol. 1 & 2, May 1988.

Mahoney, W. Means Building Construction Cost Data 1989. Construction Consultants and Publishers, 1988.

Mahoney, W. Means Site Work Cost Data 1990. Construction Consultants and Publishers, 1989.
Company, 1989.

U.S. Environmental Protection Agency. National Oil and Hazardous Substances Pollution Contingency Plan, (40 CFR 300).

U.S. Environmental Protection Agency. "Remedial Action at Waste Disposal Sites." October 1985.

U.S. Environmental Protection Agency. SITE Superfund Innovative Technology Evaluation, Technology Demonstration Summary, International Waste Technologies In Situ Stabilization/ Solidification, Hialeah, Florida. June 1989.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. "CERCLA Compliance with Other Laws Manual. Draft Guidance. August 8, 1988a. (An EPA representative said the guidance would become final in November 1989 without revisions.)

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final." October 1988b.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites." December 1988c.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. "Handbook, Remedial Action at Waste Disposal Sites (Revised)." October 1985.

U.S. Environmental Protection Agency, Office of Research and Development. "Stabilization/Solidification of CERCLA and RCRA Wastes." May 1989.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. "Obtaining a Soil and Debris Treatability Variance for Remedial Actions." Directive 9347 3-OSFS, Superfund LDR Guide #6A (2nd Edition). March 1990.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. "Technology Screening Guide for Treatment of CERCLA Soils and Sludges." September 1988.

U.S. Environmental Protection Agency, Office of Water and Waste Management. "Evaluating Cover Systems for Solid and Hazardous Waste." September 1980.

APPENDIX A
ASSUMPTIONS AND CALCULATIONS

No Action

Periodic Review Every Five Years

cost: Professional judgement.

Administration

cost: Professional judgement.

Present Worth

cost: based on a discount rate of 10% over a thirty year period.

Containment - Asphalt Cap with Slurry Wall and Well Points

Mobilization

cost: Mahoney, W. Means Site Work Cost Data 1990. p. 16. Estimate based on costs to mobilize a 300 HP dozer up to 25 miles.

Hauling

cost: Mahoney, W. 1989, p. 35. Cost based on a 20 cubic yard dump trailer traveling 4 miles round trip carrying 1.5 loads per hour and includes volumes of backfill, borrow, and loam.

Site Clearing

Clear Vegetation

cost: Mahoney, W. 1989, p.23. Estimate based on brush mowing high density vegetation using a tractor with a rotary mower. Cost includes equipment and labor. The time to clear the site is assumed to be one day.

area: assumes 1.5 acre area to be capped requires mowing.

Compact and Backfill Area

cost: Mahoney, W. Means Site Work Cost Data 1990. p. 28-29. Cost based on 6" backfill spread and compacted, forming base for cover with a maximum 2% slope for drainage. Cost assumes backfill is comprised of sand and gravel, hauled 300 feet and compacted by a riding vibrating roller in two passes.

Gravel Fill

cost: Mahoney, W. 1989. p. 37. Assume bank run gravel, spread and compacted.

Stone Fill

cost: Mahoney, W. 1989. p. 37. Assume crushed 1.5 inch stone base.

Base Course

cost: Mahoney, W. 1989. p. 37. Assume bituminous concrete.

Slurry Wall

cost: Based on EPA 1984 cost of $\$75/ft^2$ for cement/bentonite slurry wall, adjusted for urban environment and health and safety factor (U.S. EPA, 1985), updated to $81.88/ft^2 using Swift & Marshalls cost index (CE, January 1990).

area: Based on square footage of remediation area perimeters from the surface to confining clay layer. (Area 1A: 200' X 200' x 10' = 8,000 ft$_2$; Area 2: 30' x 55' x 13' = 2,210 ft^2.)

<u>Well Points</u>

cost and number: Professional judgement based on experience with UOP site investigation and similar sites.

<u>Water Disposal</u> (Included in O&M Cost)

cost: vendor quote of $.35/gallon, including transportation from northern New Jersey.

volume: Based on assumption that 10,000 gallons/year collected and require treatment.

<u>Equipment Decontamination</u>

cost: Based on monthly equipment rental and operating costs from Mahoney, W., 1989 and a $20/hour labor rate.

time: Assumed to require decontamination equipment for the duration of site operations - assumed to be 2 months (see Table 3-3).

Containment - Concrete Cap with Slurry Wall and Well Points

Mobilization

cost: Mahoney, W. Means Site Work Cost Data 1990. p. 16. Estimate based on costs to mobilize a 300 HP dozer up to 25 miles.

Hauling

cost: Mahoney, W. 1989, p. 35. Cost based on a 20 cubic yard dump trailer traveling 4 miles round trip carrying 1.5 loads per hour and includes volumes of backfill, borrow, and loam.

Site Clearing

Clear Vegetation

cost: Mahoney, W. 1989, p.23. Estimate based on brush mowing high density vegetation using a tractor with a rotary mower. Cost includes equipment and labor. The time to clear the site is assumed to be one day.

area: assumes 1.5 acre area to be capped requires mowing.

Compact and Backfill Area

cost: Mahoney, W. Means Site Work Cost Data 1990. p. 28-29. Cost based on 6" backfill spread and compacted, forming base for cover with a maximum 2% slope for drainage. Cost assumes backfill is comprised of sand and gravel, hauled 300 feet and compacted by a riding vibrating roller in two passes.

Gravel Fill

cost: Mahoney, W. 1989. p. 37. Assume bank run gravel, spread and compacted.

Stone Fill - Same as asphalt cap.

Concrete with Steel Mesh Reinforcing

cost: Mahoney, W. 1989. p. 110. Assume slab on grade, not including finish.

volume: based on a thickness of 4 inches.

Slurry Wall

cost: Based on EPA 1984 cost of $\$75/ft^2$ for cement/bentonite slurry wall, adjusted for urban environment and health and safety factor (U.S. EPA, 1985), updated to $81.88/ft^2 using Swift & Marshalls cost index (CE, January 1990).

area: Based on square footage of remediation area perimeters from the surface to confining clay layer. (Area 1A: 200' X 200' x 10' = 8,000 ft$_2$; Area 2: 30' x 55' x 13' = 2,210 ft^2.)

Well Points

cost and number: Professional judgement based on experience with UOP site investigation and similar sites.

Water Disposal (Included in O&M Cost)

cost: vendor quote of $.35/gallon, including transportation from northern New Jersey.

volume: Based on assumption that 10,000 gallons/year collected and require treatment.

Equipment Decontamination

cost: Based on monthly equipment rental and operating costs from Mahoney, W., 1989 and a $20/hour labor rate. Assumed to require decontamination equipment for duration of site activities - an estimated 2 months as shown in Table 3-3.

Site Clearing

cost: Mahoney, W. 1989, p.23. Estimate based on brush mowing high density vegetation using a tractor with a rotary mower. Cost includes equipment and labor. The time to clear the site is assumed to be one day.

Mobilize Equipment

cost: vendor quote estimated to be $1,200 per piece based on use of bigcat excavator and 3 10-wheel dump trucks in northern New Jersey.

area: assumes 1.5 acre area to be excavated requires mowing.

Remove Foundations

cost: vendor quote based on described site characteristics and northern New Jersey location. Level C health and safety mark up factor of 3.37 applied which refers to excavating wastes or contaminated soil (Environmental Law Institute, 1984).

volume: assumes concrete foundations are 3 feet thick; areas estimated from existing site maps. Eight 200 square foot foundations assumed to cover Area 1A and foundation cover in Area 2 assumed to be insignificant in remediation area.

Construct Staging Area

cost: vendor quote based on described site characteristics, soil volumes, remediation alternatives, and northern New Jersey location.

Excavation

cost: vendor quote based on cited Site conditions and proposed remedial action alternatives for excavating and transporting saturated soils less than 200 feet and less than 500 feet, incorporating a 3.37 health and safety factor (Environmental Law Institute, 1984).

volume: Estimated based on available analytical data and boring logs, conservatively assuming the VOCs will extend to the clay confining layer. The excavation volume includes the additional volume that could be excavated due to the saturated soil conditions. Additional soils excavated in Area 1A are assumed to be separable from contaminated soils. Separation of the clean soils excavated while excavating the soils to be remediated in Area 2 would be too difficult in the small area, therefore, all soils excavated in Area 2 soils are assumed to require on- or off-site treatment and or disposal. (Area 1A: Estimated remediation area of 205' x 190' to 10' depth or approximately 14,450 cy; due to saturated soils, excavation area assumed to measure 244' x 230' to 10' or approximately 20,785 cy. Therefore assume 14,500 cy require staging for further treatment and or disposal and 3,200 cy can be staged as clean soil. Area 2: Estimated remediation area of 30' x 55' to 13' depth or approximately 800 cy; due to saturated soils, excavation area assumed to measure 80' x 100' to 13' or approximately 3,900 cy. Due to small excavation area, assume entire 3,900 cy excavated requires staging for further treatment and or disposal. In summary, an estimated 3,200 cy of clean soil would be excavated and staged separate from the 14,500 cy and 3,900 cy or 18,400 cy excavated. Note that following excavation, volumes are increased by a factor of 20% to account for expansion upon excavation.

Dewatering

cost: Equipment costs from vendor quote based on use of 1 5 to 6 gallon/hour sump pump @ $60 to $80/day, hoses for $1,000/month, and a collection tank for $1,000/month. Labor estimated based on professional judgement on dewatering requirements and labor rates for northern New Jersey.

Materials Handling

cost: vendor quote based on screening and crushing excavated soil. Screening is assumed to cost $2.50/cy; crusing equipment rental and operating costs are assumed to range from $75,000 to $100,000; health and safety factor of 3.37 applied (Environmental Law Institute, 1984). (Screening: 18,400 cy * 1.2 * $2.50/cy = $55,200 + $75,000 = $130,200)

volume: Assumes that excavated soil, incorporating a 20% expansion factor for volume increase upon excavation, requires screening to separate materials greater than 4" to 6" in diameter and crushing remaining soils to the required particle size. (18,400 cy * 1.2 = 22,080 cy)

Pilot-scale Test

cost: vendor quote.

Bioremediation

cost: vendor quote, including mobilization.

volume: Soil volume assumed to be identical to screened volume presented above under Materials Handling.

time: vendor quote of six months based on cited soil volume.

Characteristic Toxicity Analyses

cost: Based on 1 sample/100 cy of treated soil at $560/sample for leaching procedure and VOCs and metals scans. (22,080 cy/100 cy * $560 = $123,648)

Backfill Treated and Clean Soil

cost: Mahoney, W. 1988. p. 282. Costs are scaled up by a factor of 8.4% based on the geographic location of New Jersey.

volume: Assumed to be the sum of the treated and clean soil, incorporating the 20% expansion/compaction factor. (18,400 cy + 3,200 cy * 1.2 = 25,920 or 26,000 cy)

Topsoil

cost: Mahoney, W. 1988 p. 40.

volume: based on estimated surface area and a 6" depth.

Seeding

cost: Mahoney, W. p. 67.

area - excavated area assumed to cover 1.5 acre, 1 acre contaminated soils and additional area to excavate saturated soils.

Excavation/Onsite Incineration

Test Burn

cost: Vendor quote

time: Assumes 2 weeks required to complete test burn based on vendor quote. The test burn includes sampling and analysis of the waste using two sets of triplicate samples.

Mobilization - Vendor quote

Site Clearing - Same as Bioremediation.

Mobilize Equipment - Same as Bioremediation.

Remove Foundations - Same as Bioremediation.

Construct Staging Area - Same as Bioremediation.

Excavation - Same as Bioremediation.

Water Treatment - Assumes water treatment system needed for the 1 month duration of excavation and dewatering at a cost of $50,000.

Materials Handling - Same as Bioremediation.

Incineration

cost: Vendor quoted range of $100 to 300/ton, therefore using $200/ton.

mass: Assume excavated volume, a 20% expansion of soil upon excavation, and density of 1.25 tons/cy based on mixture of moist loose earth and mud. (18,400 cy * 1.2 * 1.25 tons/cy = 27,600 tons)

time: Assumes vendor quoted treatment rate of 5 tons/hr, operating 24 hr/day, 7 days/week, incorporating a 40% contingency for delays due to weather and equipment maintenance. (27,600 tons * hr/5 tons * day/24 hr * 1 month/28 days * 1.4 = 11.5 or 12 months)

Backfill Treated Soil (Ash)

cost: Vendor quote assumes the treated soil is not characteristically hazardous and can be used as backfill in the excavation areas.

volume: Assumes ash is equal to treated volume based on vendor quote.

Backfill Clean Soil

cost: Mahoney, W. 1988. p. 282. Costs are scaled up by a factor of 8.4% based on the geographic location of New Jersey.

volume: Assumed to be the volume of clean soil excavated with the soils to be incinerated, incorporating the 20% expansion/compaction factor. (3,200 cy * 1.2 = 3,840 cy)

Demobilization - Vendor quote.

Topsoil - Same as Bioremediation.

Seeding - Same as Bioremediation.

Excavation/Offsite Incineration

Site Clearing - Same as Bioremediation.

Mobilize Equipment - Same as Bioremediation.

Remove Foundations - Same as Bioremediation.

Excavation - Same as Bioremediation.

Water Treatment - Assumes water treatment system needed for the 1 month duration of excavation and dewatering at a cost of $50,000.

Characterization - Vendor quote.

Offsite Incineration

cost: Vendor quote of $1.15/# based on bulk soil shipment.

volume: Same as onsite incineration.

Transportation

cost: Vendor quote of $3/loaded mile and an estimated distance of 1,350 miles from East Rutherford to El Dorado, Arkansas, assuming 20 tons/load. (27,600 tons * load/20 tons = 1,380 loads * $3/mile * 1,350 miles/load = $5,589,000)

Clean Backfill Material

cost: Assumed to cost $20/cy for certified clean fill, hauled and spread, in northern New Jersey based on professional judgement.

volume: Assume excavated volume with a 20% adjustment factor for expansion and compaction. (18,400 * 1.2 = 22,080 cy)

Backfill Clean Soil

cost: Mahoney, W. 1988. p. 282. Costs are scaled up by a factor of 8.4% based on the geographic location of New Jersey.

volume: Assumed to be the volume of clean soil excavated with the soils to be incinerated, incorporating the 20% expansion/compaction factor. (3,200 cy * 1.2 = 3,840 cy)

Topsoil - Same as onsite incineration.

Seeding - Same as onsite incineration.

Equipment Decontamination

cost: Same as asphalt cap.

time: Assumed to require decontamination equipment for the duration of site operations - assumed to be 24 months due to facility capacity limitations and potential scheduling delays (see attached schedule).

Excavation/Soil Washing

Bench Scale Study - Vendor quote.

Mobilization - Vendor quote.

Site Clearing - Same as Bioremediation.

Mobilize Excavation Equipment - Same as Bioremediation.

Remove Foundations - Same as Bioremediation.

Construct Staging Area - Same as Bioremediation.

Excavation - Same as Bioremediation.

Water Treatment - Assumes water treatment system needed for the 1 month duration of excavation and dewatering at a cost of $50,000.

Materials Handling - Same as onsite incineration.

Soil Washing

cost: Vendor quote.

volume: Same as Bioremediation.

time: Vendor quoted unit operating rate of 75 cy/day and incorporating a 40% contingency factor for weather delays and equipment maintenance. (22,080 cy * day/75 cy * 1 month/28 days * 1.4 = 10.5 or 11 months)

Characteristic Toxicity Analyses

cost: Based on 1 sample/100 cy of treated soil at $560/sample for leaching procedure and VOCs and metals scans. (22,080 cy/100 cy * $560 = $123,648)

Backfill Clean and Treated Soil -

cost: Mahoney, W. 1988. p. 282. Costs are scaled up by a factor of 8.4% based on the geographic location of New Jersey.

volume: Assumes the treated soil is not characteristically hazardous and can be returned to the excavated areas. Volume assumed to equal the sum of the volume of clean and treated soil, accounting for the 20% adjustment for expansion and compaction. (25,920 cy)

Topsoil - Same as onsite incineration.

Seeding - Same as onsite incineration.

Incinerate Oil Offsite

cost: Vendor quote of $0.45/# based on bulk liquids.(276,000# * $0.45/# = $124,200)

mass: Oil is assumed to comprise 0.5% of the total mass of soil treated based on vendor-supplied material balance. (22,080 cy * 1.25 tons/cy * 0.005 * 2,000#/ton = 276,000#)

Transportation of Oil

cost: Vendor quote of $3.25/loaded mile for 20,000 gallon tanker trucks. (2 loads * $3.25/mile * 1,350 miles/load = $8,776) (Number of loads is calculated below.)

volume: Assume 20,000 gallon tanker trucks transporting oil, assuming specific gravity of the oil phase is 0.9. (22,080 cy * 1.25 tons/cy * 0.005 * 2,000#/ton / (8.33#/gal * 0.9)/20,000 gal/load = 1.7 or 2 loads)

Excavation/Thermal Separation

Bench Scale Study - Vendor quote.

Pilot Study - Vendor quote.

Mobilization - Vendor quote.

Site Clearing - Same as Bioremediation.

Mobilize Excavation Equipment - Same as Bioremediation.

Remove Foundations - Same as Bioremediation.

Construct Staging Area - Same as Bioremediation.

Excavation - Same as Bioremediation.

Water Treatment - Assumes water treatment system needed for the 1 month duration of excavation and dewatering at a cost of $50,000.

Materials Handling - Same as onsite incineration.

Thermal Separation

cost: Vendor quote.

mass: 27,600 tons, see onsite incineration.

time: Vendor quoted treatment rate ranges from 50 to 180 tons/day. Assume 115 tons/day, operating 24 hours/day, 28 days/month, incorporating a 40% contingency factor for delays due to weather and equipment maintenance. (27,600 tons * day/115 tons * month/28 days * 1.4 = 12 months)

Characteristic Toxicity Analyses - Same as soil washing.

Backfill Clean and Treated Soil -

cost: Mahoney, W. 1988. p. 282. Costs are scaled up by a factor of 8.4% based on the geographic location of New Jersey.

volume: Assumes the treated soil is not characteristically hazardous and can be returned to the excavated areas. Volume assumed to equal the sum of the volume of clean and treated soil, accounting for the 20% adjustment for expansion and compaction. (25,920 cy)

Topsoil - Same as onsite incineration.

Seeding - Same as onsite incineration.

Offsite Incineration
of Filter Cake cost: refer to offsite incineration.

mass: Based on vendor-supplied material balance (attached) in which the filter cake represents approximately 1.65% of the mass treated. (0.0165 * 27,600 tons * 2,000 lb/ton = 910,800 lb)

Transportation of
Filter Cake cost: Vendor quote of $3/loaded mile, assuming 20 ton loads and a distance of 1,350 miles. (27,600 tons * 0.0165 * load/20 tons * $3/mile * 1,350 miles/load = $92,220)

Offsite Incineration
of Condensate cost: Vendor quote of $0.45/# based on bulk liquids with less than 10,000 ppm PCB concentrations, mass calculated below. (836,550# * $0.45/# = $376,448)

mass: Assume oil fraction of the condensate represents 0.5% of the mass of the treated soil, water phase is assumed to be suitable to be used for dust control. (22,080 cy * 1.25 tons/cy * 0.005 * 2,000#/ton = 276,000#)

Transportation of
Condensate cost: Vendor quote of $3.25/loaded mile for 20,000 gallon tanker trucks. (2 loads * $3.25/mile * 1,350 miles/load = $8,776) (Number of loads is calculated below.)

volume: Assume 20,000 gallon tanker trucks transporting oil, assuming specific gravity of the oil phase is 0.9. (22,080 cy * 1.25 tons/cy * 0.005 * 2,000#/ton / (8.33#/gal * 0.9)/20,000 gal/load = 1.7 or 2 loads)

Vacuum Extraction

Pilot-scale Test - Vendor quote.

Site Clearing - Same as Bioremediation.

Mobilize Excavation Equipment - Same as Bioremediation.

Remove Foundations - Same as Bioremediation.

Construct Staging Area - Same as Bioremediation.

Excavation - Same as Bioremediation.

Water Treatment - Assumes water treatment system needed for the 1 month duration of excavation and dewatering at a cost of $50,000.

Materials Handling - Same as onsite incineration.

Vacuum Extraction - Vendor quote of $100/cy including mobilization.

Characteristic Toxicity Analyses

cost: Based on 1 sample/100 cy of treated soil at $560/sample for leaching procedure and VOCs and metals scans. (22,080 cy/100 cy * $560 = $123,648)

Backfill Clean and Treated Soil -

cost: Mahoney, W. 1988. p. 282. Costs are scaled up by a factor of 8.4% based on the geographic location of New Jersey.

volume: Assumes the treated soil is not characteristically hazardous and can be returned to the excavated areas. Volume assumed to equal the sum of the volume of clean and treated soil, accounting for the 20% adjustment for expansion and compaction. (25,920 cy)

Topsoil - Same as onsite incineration.

Seeding - Same as onsite incineration.

Offsite Disposal

Characterization

cost: Vendor quote.

Site Clearing - Same as Bioremediation.

Mobilize Excavation Equipment - Same as Bioremediation.

Remove Foundations - Same as Bioremediation.

Excavation - Same as Bioremediation.

Water Treatment - Assumes water treatment system needed for the 1 month duration of excavation and dewatering at a cost of $50,000.

Dewatering Excavated Soils

cost: Assumes excavated soils will have to be dewatered using a belt filter press or similar dewatering equipment at a fixed cost of $65,000.

volume: Assumes all excavated soils will have to be dewatered prior to offsite transport (22,080).

Offsite Disposal

cost: $175/ton based on vendor quote.

volume: Assume excavated volume and a 20% adjustment factor for expansion upon excavation and 1.25 tons/cy. (18,400 cy * 1.2 * 1.25 tons/cy = 27,600 tons)

State Tax

cost: Vendor quote based on site location and destination.

Local Tax - Same as state tax above.

Transportation

cost: based on $3.25 per loaded mile, 20 tons/load, and an estimated 600 miles from East Rutherford, NJ to Buffalo, NY. ($3.25/mile * 600 miles * 27,600 tons/20 tons = $2,691,000)

Backfill Material - Same as offsite incineration.

Topsoil - Same as Bioremediation.

Seeding - Same as Bioremediation.

Equipment Decontamination - Same as single-layer cap.

In-Situ Vacuum Extraction

Site Clearing - Same as Bioremediation.

Pneumatic Fracturing

cost: Based on New Jersey Institute of Technology (NJIT) quote of $11,000 for equipment, $1,000/day for drilling, and $600/day for labor and quoted fracturing rate of 4 to 5 holes/day. A health and safety factor of 1.17 applied (Environmental Law Institute, 1984).

number: Based on NJIT results that indicate an effective radius of 5 feet in unsaturated silts and clays. At 10-foot intervals, 400 points will be needed in Area 1A and 15 points will be needed in Area 2.

Maintenance costs assume that pneumatic fracturing will have to be repeated six times during vacuum extraction; each round of maintenance fracturing is estimated to cost half the initial fracturing cost.

Pilot-scale Study - Vendor quote.

Vacuum Extraction

cost: Vendor quote based on cited Site conditions, includes cost of dewatering and liquid and vapor treatment.

Site Restoration - Same as topsoil and seeding presented in onsite incineration.

TABLE A-1

UOP Site - Area 1A & 2
Operation and Maintenance Cost Estimate
No Action

Cost Component	Annual Cost	Five Year Cost
Periodic Review Every five years		$20,000
Administration	$1,000	
Total Cost per Period	$1,000	$20,000
Present Worth *	$9,000	$31,000

Total Present Worth = $40,000

* The present worth is calculated using a discount rate of 10% over a thirty year period.

TABLE A-2a

UOP Site - Area 1A & 2
Operation and Maintenance Cost Estimate
Bituminous Asphalt Cap

Cost Component	Annual Cost	Five Year Cost
Periodic Review Every Five Years		$20,000
Inspection and Maintenance	$4,000	
Water Disposal	$3,500	
Administration	$1,000	
Total Cost per Period	$8,500	$20,000
Present Worth *	$80,000	$31,000

Total Present Wort $111,000

* The present worth is calculated with a discount rate of 10% over a thirty year period.

04/18/90

TABLE A-2a (continued)

UOP Site - Area 1A & 2
Present Worth Cost Estimate
Bituminous Asphalt Cap

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Site Clearing (acre)	1	$550.00	$550	1.00	$550
Compact and Backfill Area (6") (sy)	4,498	$2.20	$9,896	1.00	$9,896
Gravel Fill (6") spread and compacted (square yard)	4,498	$2.27	$10,211	1.00	$10,211
Stone Fill (12") spread and compacted (square yard)	4,498	$10.16	$45,703	1.00	$45,703
Base Course (4") (square yard)	4,498	$8.55	$38,461	1.00	$38,461
Slurry Wall (square feet)	10,200	$81.88	$835,176	1.00	$835,176
Well Points	7	$1,000.00	$7,000	1.00	$7,000
Equipment Decontamination (month)	2	$2,500.00	$5,000	1.00	$5,000
Direct Capital Cost			$951,997		$951,997
Engineering and Supervision (15%)			$142,800		$142,800
Construction and Field Expenses (5%)			$47,600		$47,600
Contractor's Fees (7.5%)			$71,400		$71,400
Contingencies (20%)			$190,399		$190,399
Capital Cost			$1,404,196		$1,404,196
1 Year O & M			$5,000		$5,000
Total Capital Cost			$1,409,196		$1,409,196
Present Worth O&M			$111,000		$111,000
Total Present Worth Cost			$1,520,196		$1,520,196

TABLE A-2b

UOP Site - Area 1A & 2
Operation and Maintenance Cost Estimate
Concrete Cap

Cost Component	Annual Cost	Five Year Cost
Periodic Review Every Five Years		$20,000
Inspection and Maintenance	$4,000	
Water Disposal	$3,500	
Administration	$1,000	
Total Cost per Period	$8,500	$20,000
Present Worth *	$80,000	$31,000

Total Present Worth = $111,000

* The present worth is calculated with a discount rate of 10% over thirty year period.

04/18/90

TABLE A-2b (continued)

UOP Site - Area 1A & 2
Present Worth Cost Estimate
Concrete Cap

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Site Clearing (acre)	1	$550.00	$550	1.00	$550
Compact and Backfill Area (6") (sy)	4,498	$2.20	$9,896	1.00	$9,896
Gravel Fill (6") spread and compacted (square yard)	4,498	$2.27	$10,211	1.00	$10,211
Stone Fill (12") spread and compacted (square yard)	4,498	$10.16	$45,703	1.00	$45,703
Concrete (4") with reinforcing steel mesh (cy)	500	$123.63	$61,792	1.00	$61,792
Slurry Wall (square feet)	10,200	$81.88	$835,176	1.00	$835,176
Well Points	7	$1,000.00	$7,000	1.00	$7,000
uipment Decontamination (month)	2	$2,500.00	$5,000	1.00	$5,000
Direct Capital Cost			$975,329		$975,329
Engineering and Supervision (15%)			$146,299		$146,299
Construction and Field Expenses (5%)			$48,766		$48,766
Contractor's Fees (7.5%)			$73,150		$73,150
Contingencies (20%)			$195,066		$195,066
Capital Cost			$1,438,610		$1,438,610
1 Year O & M			$5,000		$5,000
Total Capital Cost			$1,443,610		$1,443,610
Present Worth O&M			$111,000		$111,000
Total Present Worth Cost			$1,554,610		$1,554,610

04/18/90

TABLE A-3

UOP Site - Area 1A & 2
Capital Cost Estimate
Bioremediation

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Site Clearing					
Clear vegetation (acre)	1.5	$550.00	$825	1.00	$825
Remove foundations (cubic yard)	165	$200.00	$33,000	3.37	$111,210
Construct Staging Area (day)	5	$3,480.00	$17,400	1.00	$17,400
Mobilize Equipment	4	$1,200.00	$4,800	1.00	$4,800
Soil Excavation (cubic yard)					
Transporting 200 ft (cubic yard)	3,200	$2.00	$6,400	3.37	$21,568
Transporting 500 ft (cubic yard)	18,400	$3.00	$55,200	3.37	$186,024
Dewatering					
Equipment (day)	28	$150.00	$4,200	1.00	$4,200
Labor (4 hr/day)	112	$20.00	$2,240	1.21	$2,710
Materials Handling			$130,000	3.37	$438,100
Pilot Scale Test			$50,000	1.00	$50,000
Bioremediation (cubic yard)	22,080	$125.00	$2,760,000	1.00	$2,760,000
Characteristic Toxicity Analysis	220	560	$123,200	1.00	$123,200
Backfill Clean and Treated Soil (cy)	25,920	$1.84	$47,693	1.00	$47,693
Topsoil (square yard) (Delivered, Spread, & Compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Direct Capital Cost			$3,211,896		$3,666,458
Engineering and Supervision (15%)			$481,784		$549,969
Construction and Field Expenses (5%)			$160,595		$183,323
Contractor's Fees (7.5%)			$240,892		$274,984
Contingencies (20%)			$642,379		$733,292
Total Capital Cost			$4,737,546		$5,408,026

04/18/90

TABLE A-4

UOP Site - Area 1A & 2
Capital Cost Estimate
Onsite Incineration

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Test Burn			$300,000	1.00	$300,000
Mobilization			$830,000	1.00	$830,000
Site Clearing					
Equipment (each piece)	4	$1,200.00	$4,800	1.00	$4,800
Clear vegetation (acre)	1.5	$550.00	$825	1.00	$825
Remove foundations (cubic yard)	165	$200.00	$33,000	3.37	$111,210
Staging area construction (day)	5	$3,480.00	$17,400	1.00	$17,400
Soil Excavation (cubic yard)					
Transporting 200 ft (cubic yard)	3,200	$2.00	$6,400	3.37	$21,568
Transporting 500 ft (cubic yard)	18,400	$3.00	$55,200	3.37	$186,024
Dewatering					
Equipment (day)	28	$150.00	$4,200	1.00	$4,200
Labor (4 hr/day)	112	$20.00	$2,240	1.21	$2,710
Water Treatment			$50,000	1.00	$50,000
Materials Handling			$130,000	3.37	$438,100
Onsite Incineration (ton)	27,600	$200.00	$5,520,000	1.00	$5,520,000
Backfill Treated & Clean Soil (cy)	25,920	$1.84	$47,693	1.00	$47,693
Demobilization			$500,000	1.00	$500,000
Topsoil (square yard) (Delivered, Spread, & Compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Direct Capital Cost			$7,529,921		$8,062,693
Engineering and Supervision (15%)			$1,129,488		$1,209,404
Construction and Field Expenses (5%)			$376,496		$403,135
Contractor's Fees (7.5%)			$564,744		$604,702
ontingencies (20%)			$1,505,984		$1,612,539
Total Capital Cost			$11,106,633		$11,892,473

04/18/90

TABLE A-5

UOP Site - Area 1A & 2
Capital Cost Estimate
Offsite Incineration

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Site Clearing					
Equipment (each piece)	4	$1,200.00	$4,800	1.00	$4,800
Clear vegetation (acre)	1.5	$550.00	$825	1.00	$825
Remove foundations (cubic yard)	165	$200.00	$33,000	3.37	$111,210
Staging area construction (day)	5	$3,480.00	$17,400	1.00	$17,400
Soil Excavation (cubic yard)					
Transporting 200 ft (cubic yard)	3,200	$2.00	$6,400	3.37	$21,568
Transporting 500 ft (cubic yard)	18,400	$3.00	$55,200	3.37	$186,024
Dewatering					
Equipment (day)	28	$150.00	$4,200	1.00	$4,200
Labor (4 hr/day)	112	$20.00	$2,240	1.21	$2,710
Water Treatment			$50,000	1.00	$50,000
Materials Handling			$130,000	3.37	$438,100
Characterization			$300	1.00	$300
Offsite Incineration (lb)	55,200,000	$1.15	$63,480,000	1.00	$63,480,000
Transportation (20 ton load)	1,380	$4,050.00	$5,589,000	1.00	$5,589,000
Backfill Clean Fill (cubic yard)	22,080	$20.00	$441,600	1.00	$441,600
Backfill Clean Soil (cy)	3,840	$1.84	$7,066	1.00	$7,066
Topsoil (square yard) (Delivered, Spread, & Compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Equipment Decontamination (month)	36	$2,500.00	$90,000	1.00	$90,000
Direct Capital Cost			$69,940,194		$70,472,966
Engineering and Supervision (15%)			$10,491,029		$10,570,945
Construction and Field Expenses (5%)			$3,497,010		$3,523,648
Contractor's Fees (7.5%)			$5,245,515		$5,285,472
Contingencies (20%)			$13,988,039		$14,094,593
Total Capital Cost			$103,161,786		$103,947,625

04/18/90

TABLE A-6

UOP Site - Area 1A & 2
Capital Cost Estimate
Soil Washing

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Bench Scale Study			$5,500	1.00	$5,500
Mobilization			$150,000	1.00	$150,000
Site Clearing					
Equipment (each piece)	4	$1,200.00	$4,800	1.00	$4,800
Clear vegetation (acre)	1.5	$550.00	$825	1.00	$825
Remove foundations (cubic yard)	165	$200.00	$33,000	3.37	$111,210
Staging area construction (day)	5	$3,480.00	$17,400	1.00	$17,400
Soil Excavation (cubic yard)					
Transporting 200 ft (cubic yard)	3,200	$2.00	$6,400	3.37	$21,568
Transporting 500 ft (cubic yard)	18,400	$3.00	$55,200	3.37	$186,024
Dewatering					
Equipment (day)	28	$150.00	$4,200	1.00	$4,200
Labor (4 hr/day)	112	$20.00	$2,240	1.21	$2,710
Water Treatment			$50,000	1.00	$50,000
Materials Handling			$130,000	3.37	$438,100
Soil Washing (cubic yard)	22,080	$250.00	$5,520,000	1.00	$5,520,000
Char. Toxicity Anal. (100 cy/sample)	221	$560.00	$123,648	1.00	$123,648
Backfill Clean and Treated Soil (cy)	25,920	$1.84	$47,693	1.00	$47,693
Topsoil (square yard) (Delivered, Spread, & Compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Incinerate oil offsite					
Incineration (lb)	276,000	$0.45	$124,200	1.00	$124,200
Transportation (20 kgal load)	2	$4,388.00	$8,067	1.00	$8,067
Direct Capital Cost			$6,311,336		$6,844,109
Engineering and Supervision (15%)			$946,700		$1,026,616
Construction and Field Expenses (5%)			$315,567		$342,205
Contractor's Fees (7.5%)			$473,350		$513,308
Contingencies (20%)			$1,262,267		$1,368,822
Total Capital Cost			$9,309,221		$10,095,060

04/18/90

TABLE A-7

UOP Site - Area 1A & 2
Capital Cost Estimate
Thermal Separation

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Bench Scale Study			$10,000	1.00	$10,000
Pilot Study			$50,000	1.00	$50,000
Mobilization			$700,000	1.00	$700,000
Site Clearing					
Equipment (each piece)	4	$1,200.00	$4,800	1.00	$4,800
Clear vegetation (acre)	1.5	$550.00	$825	1.00	$825
Remove foundations (cubic yard)	165	$200.00	$33,000	3.37	$111,210
Staging area construction (day)	5	$3,480.00	$17,400	1.00	$17,400
Soil Excavation (cubic yard)					
Transporting 200 ft (cubic yard)	3,200	$2.00	$6,400	3.37	$21,568
Transporting 500 ft (cubic yard)	18,400	$3.00	$55,200	3.37	$186,024
Dewatering					
Equipment (day)	28	$150.00	$4,200	1.00	$4,200
Labor (4 hr/day)	112	$20.00	$2,240	1.21	$2,710
Water Treatment			$50,000	1.00	$50,000
Materials Handling			$130,000	3.37	$438,100
Thermal Separation (ton)	27,600	$175.00	$4,830,000	1.00	$4,830,000
Char. Toxicity Analysis (100 cy)	221	$560.00	$123,648	1.00	$123,648
Backfill Clean and Treated Soil (cy)	25,920	$1.84	$47,693	1.00	$47,693
Topsoil (square yard) (Delivered, Spread, & Compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Filter Cake					
Transportation (20 ton load)	23	$4,050.00	$92,219	1.00	$92,219
Incineration (lb)	910,800	$1.15	$1,047,420	1.00	$1,047,420
Condensate					
Incineration (lb)	276,000	$0.45	$124,200	1.00	$124,200
Transportation (20 kgal load)	2	$4,388.00	$8,067	1.00	$8,067
Direct Capital Cost			$7,365,475		$7,898,247
Engineering and Supervision (15%)			$1,104,821		$1,184,737

04/18/90

TABLE A-7 (continued)

UOP Site - Area 1A & 2
Capital Cost Estimate
Thermal Separation

Construction and Field Expenses (5%)	$368,274	$394,912
Contractor's Fees (7.5%)	$552,411	$592,369
Contingencies (20%)	$1,473,095	$1,579,649
Total Capital Cost	$10,864,075	$11,649,915

04/18/90

TABLE A-8

UOP Site - Area 1A & 2
Capital Cost Estimate
Vacuum Extraction

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Pilot Scale Test			$55,000	1.00	$55,000
Site Clearing					
Equipment (each piece)	4	$1,200.00	$4,800	1.00	$4,800
Clear vegetation (acre)	1	$550.00	$550	1.00	$550
Remove foundations (cubic yard)	165	$200.00	$33,000	3.37	$111,210
Staging area construction (day)	5	$3,480.00	$17,400	1.00	$17,400
Soil Excavation (cubic yard)					
Transporting 200 ft (cubic yard)	3,200	$2.00	$6,400	3.37	$21,568
Transporting 500 ft (cubic yard)	18,400	$3.00	$55,200	3.37	$186,024
Dewatering					
Equipment (day)	28	$150.00	$4,200	1.00	$4,200
Labor (4 hr/day)	112	$20.00	$2,240	1.21	$2,710
Water Treatment			$50,000	1.00	$50,000
terials Handling			$130,000	3.37	$438,100
Vacuum Extraction (cubic yard)	22,080	$100.00	$2,208,000	1.00	$2,208,000
Char. Toxicity Analysis (100 cy)	221	$560.00	$123,648	1.00	$123,648
Backfill Treated & Clean Soil (cy)	25,920	$1.84	$47,693	1.00	$47,693
Topsoil (square yard) (delivered, spread, & compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Direct Capital Cost			$2,766,294		$3,299,066
Engineering and Supervision (15%)			$414,944		$494,860
Construction and Field Expenses (5%)			$138,315		$164,953
Contractor's Fees (7.5%)			$207,472		$247,430
Contingencies (20%)			$553,259		$659,813
Total Capital Cost			$4,080,284		$4,866,123

04/18/90

TABLE A-9

UOP Site - Area 1A & 2
Capital Cost Estimate
Offsite Disposal

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Site Clearing					
Equipment (each piece)	4	$1,200.00	$4,800	1.00	$4,800
Clear vegetation (acre)	1.5	$550.00	$825	1.00	$825
Remove foundations (cubic yard)	165	$200.00	$33,000	3.37	$111,210
Staging area construction (day)	5	$3,480.00	$17,400	1.00	$17,400
Soil Excavation (cubic yard)					
Transporting 200 ft (cubic yard)	3,200	$2.00	$6,400	3.37	$21,568
Transporting 500 ft (cubic yard)	18,400	$3.00	$55,200	3.37	$186,024
Dewatering					
Equipment (day)	28	$150.00	$4,200	1.00	$4,200
Labor (4 hr/day)	112	$20.00	$2,240	1.21	$2,710
Water Treatment			$50,000	1.00	$50,000
Soil Dewatering			$65,000	3.37	$219,050
Offsite Disposal (ton)	27,600	$175.00	$4,830,000	1.00	$4,830,000
State Tax (ton)	27,600	$27.00	$745,200	1.00	$745,200
Local Tax (5% of gross receipts)			$27,876	1.00	$27,876
Transportation (20 ton load)	1,380	$1,950.00	$2,691,000	1.00	$2,691,000
Backfill Clean Fill (cubic yard)	22,080	$20.00	$441,600	1.00	$441,600
Backfill Clean Soil (cubic yard)	3,840	$1.84	$7,066	1.00	$7,066
Topsoil (square yard) (delivered, spread, & compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Equipment Decontamination (month)	2	$2,500.00	$5,000	1.00	$5,000
Direct Capital Cost			$9,014,970		$9,393,692
Engineering and Supervision (15%)			$1,352,245		$1,409,054
Construction and Field Expenses (5%)			$450,748		$469,685
Contractor's Fees (7.5%)			$676,123		$704,527
Contingencies (20%)			$1,802,994		$1,878,738
Total Capital Cost			$13,297,080		$13,855,696

04/18/90

TABLE A-10

UOP Site - Area 1A & 2
Capital Cost Estimate
Vacuum Extraction In-situ

Cost Component	Quantity	Unit Cost	Base Cost	H&S Level Factor	Total Cost
Site Clearing					
Equipment (each piece)	2	$1,200.00	$2,400	1.00	$2,400
Clear vegetation (acre)	1	$550.00	$550	1.00	$550
Pilot Scale Test			$66,000	1.00	$66,000
Pneumatic Fracturing					
Equipment			$11,000	1.00	$11,000
Drilling (day)	83	$1,000.00	$83,000	1.17	$97,110
Labor (day)	83	$600.00	$49,800	1.17	$58,266
Fracturing Maintenance	6	$71,900	$431,400	1.17	$504,738
Vacuum Extraction (lump sum) *			$1,275,000	1.00	$1,275,000
Topsoil (square yard) (delivered, spread, & compacted)	7,178	$3.79	$27,204	1.00	$27,204
Seeding (acre)	1.5	$639.56	$959	1.00	$959
Direct Capital Cost			$1,947,313		$2,043,227
Engineering and Supervision (15%)			$292,097		$306,484
Construction and Field Expenses (5%)			$97,366		$102,161
Contractor's Fees (7.5%)			$146,048		$153,242
Contingencies (20%)			$389,463		$408,645
Total Capital Cost			$2,872,287		$3,013,760

* Includes dewatering and liquid and vapor treatment.